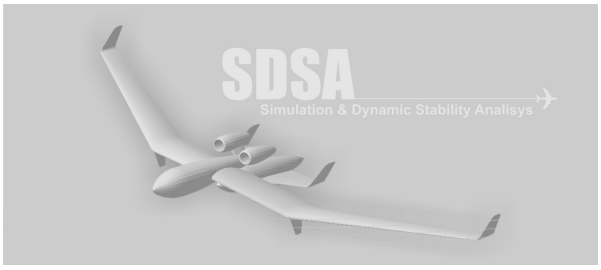

SDSA – User manual

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1 SDSA Software main functionalities (SDSA modules)

- **Stability analysis:**
  - eigenvalues analysis,
  - time history identification analysis,
  - static margins (stick fixed, free).
- **6 DoF simulation:**
  - test flights, incl. trim response & LQR,
  - tests incl. turbulence, (Dryden turbulence model – future design).
- **LQR based Flight Control System:**
  - tests incl. Pilot in the Loop model & Stability Argumentation System.
- **Performance:**
  - envelope, range & endurance,
  - manoeuvres, external performance module,
- **Miscellaneous (data check, review, results review, cross plots, XML and TEXT file input/ output data file structure, other etc.)**

Fig. 1.1 - SDSA – About window screen

2 SDSA User graphical interface

2.1 SDSA main application window

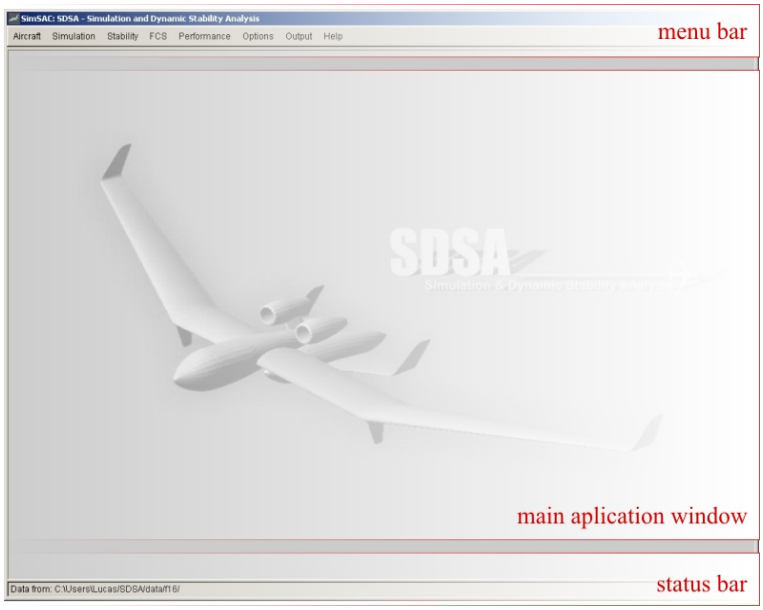


Fig. 2.1 - SDSA – Main application window

The SDSA main application window is now divided into three main areas:

- *menu bar*, (user can access the particular program modules by clicking the proper menu button),

- *main application window*, (this is the workspace of the SDSA program),
- *status bar*, (where the necessary text information is being displayed).

Useful information:

- The *main application workspace window* changes when the user accesses the SDSA modules.
- Some of the enclosed SDSA modules are being displayed in external stand alone windows.
- To clean the main application workspace window and display the start-up screen go to application menu bar *options/ clear window* or press *F12* key.
- Press *ESC* key on keyboard to "kill" SDSA application.

2.2 SDSA application GUI interface elements:

GUI interacts with user through several interface elements: various push buttons, slide rulers, radio buttons, text fields etc. The essential examples with short description are shown on the next page:

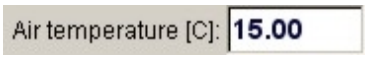
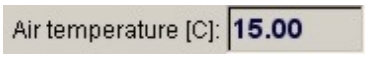
	- SDSA standard functional push button example,
	- SDSA data input fields (white background),
	- SDSA data output fields (grey background),
	- SDSA slider,
	- SDSA radio button,

Table 01 SDSA – GUI elements examples

Most of interface elements adapt to the SDSA window resolution.

3 SDSA menus quick review

The SDSA menu bar is divided into several submenus. Each submenu includes button link to the corresponding SDSA application feature.

3.1 Aircraft submenu

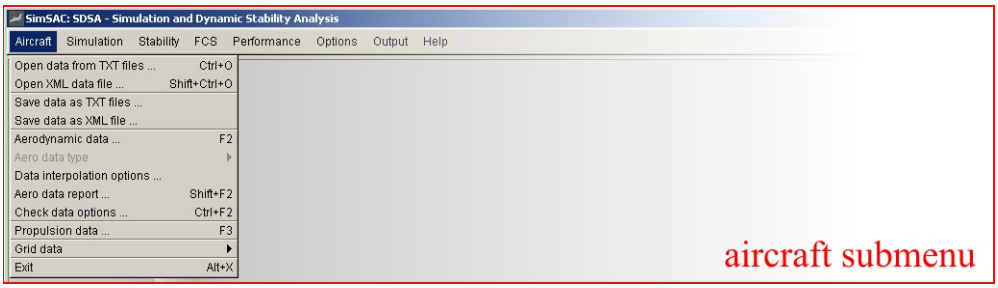


Fig. 3.1 - SDSA – Aircraft submenu

Command	Short cut key combination	Description
Open data from TXT files ...	*Ctrl+O*	- click to select path to input TXT data files (standard external Windows - folder selection window is being displayed), (see Fig. 3.2),
Open XML data file ...	*Shift+Ctrl+O*	- click to select the input XML single data file (standard external Windows - file selection window is being displayed), (see Fig. 3.3),
Save data as TXT files ...	-	- click to save data path to input TXT data files (standard external Windows - save folder location window is being displayed), (see Fig. 3.2),
Save data as XML file ...	-	- click to save the input XML single data file (standard external Window - save file window is being displayed) (see Fig. 3.4),
Aerodynamic data ...	*F2*	- click to open the internal SDSA aerodynamic input data review window, (see Fig. 3.5),
Aero data type ...	-	When the input aerodynamic data is stored in multidimensional array, where all coefficients are stored as function of state vector, user can select between: • Multivariable tables • Stability derivatives to use during computations in SDSA software. (for more information see **SDSA – Input data file structure manual**)
Data interpolation options ...	-	- click to open the internal SDSA interpolation options window, (see Fig. 3.9),
Aero data report ...	*Shift+F2*	- click to generate the SDSA aero data report (see Fig. 3.7),
Check data options ...	*Ctrl+F2*	- click to open the internal SDSA check data options window, (see Fig. 3.8),
Propulsion data ...	*F3*	- click to open the internal SDSA propulsion system options window, (see Fig. 3.10),
Grid data ...	-	- click to choose the grid file (default or selected by user grid file)
Exit	*Alt+X*	- click to completely exit SDSA application,

Table 02 SDSA – Aircraft submenu description

3.1.1 Open data location/ file …

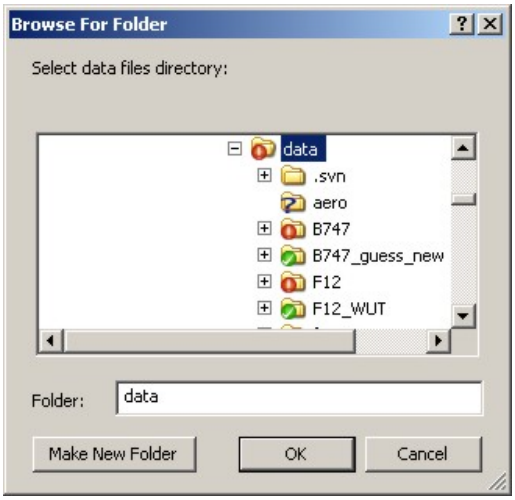


Fig. 3.2 - SDSA – TXT input data files folder location selection external window

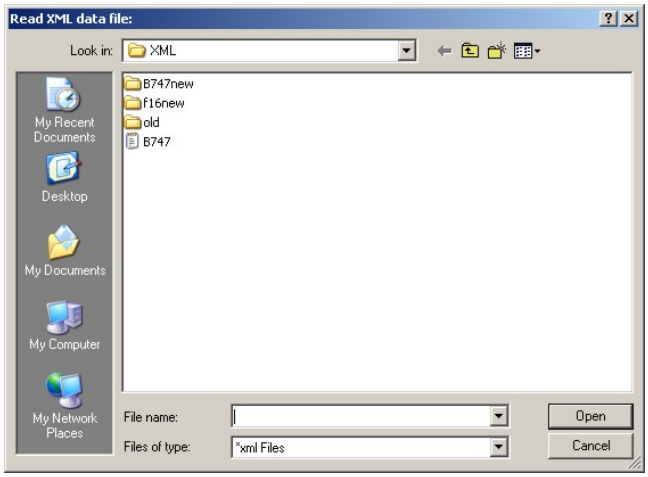


Fig. 3.3 - SDSA – XML single input data file selection external window

3.1.2 Save data location/ file …

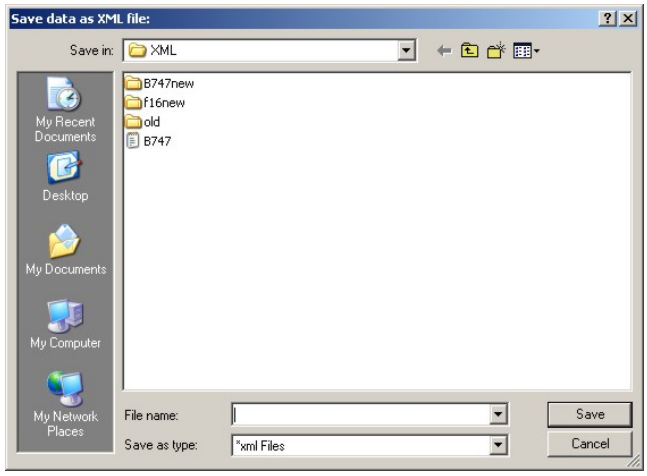


Fig. 3.4 - SDSA – XML single input data save file external window

3.1.3 Aerodynamic data review …

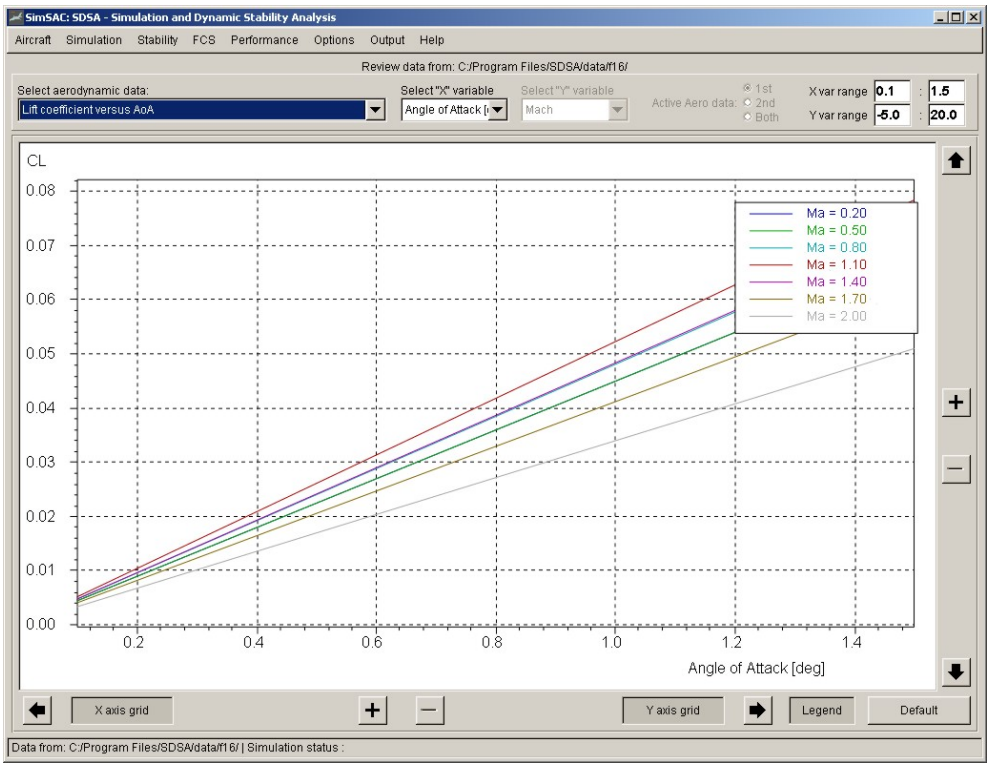


Fig. 3.5 - SDSA – Review aerodynamic input data, internal SDSA window

Information about SDSA aerodynamic input data review features:

- User can choose from the selection list the desired input data to be shown on graph versus selected X and Y variable (the type of variable depends on input data).
- The X and Y variable range can be defined by filing the appropriate input fields.
- User can also activate the desired *Aero data set* (if there is more than one available).
- The check data result summary external window, will appear when user activates aerodynamic data review feature for the first time, (see Fig. 3.6) and output report window (see Fig. 3.7) .

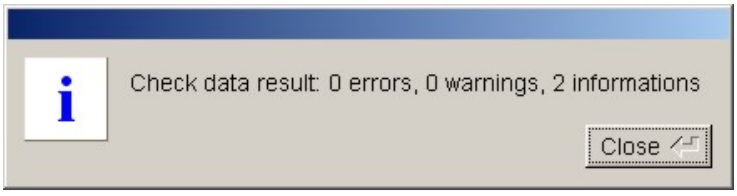


Fig. 3.6 - SDSA – Check data result external window

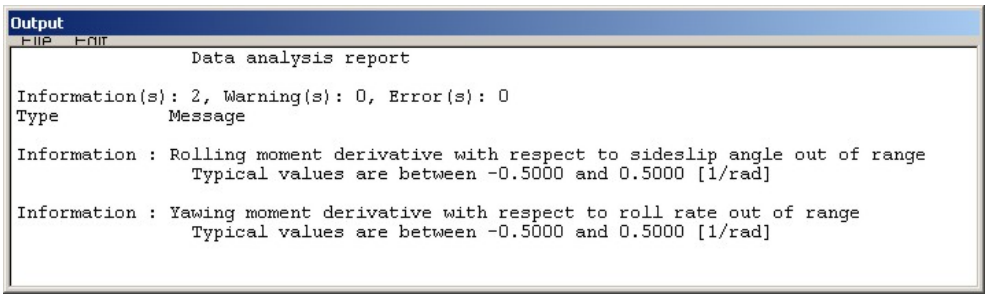

Output
File Edit
Data analysis report
Information(s): 2, Warning(s): 0, Error(s): 0
Type Message
Information : Rolling moment derivative with respect to sideslip angle out of range
Typical values are between -0.5000 and 0.5000 [1/rad]
Information : Yawing moment derivative with respect to roll rate out of range
Typical values are between -0.5000 and 0.5000 [1/rad]

Fig. 3.7 - SDSA – Output aerodynamic data report external window

- User can access the aerodynamic data report window (see Fig. 3.7) .by clicking the *Aero data report button* from *Aircraft submenu*.

3.1.4 Check data options …

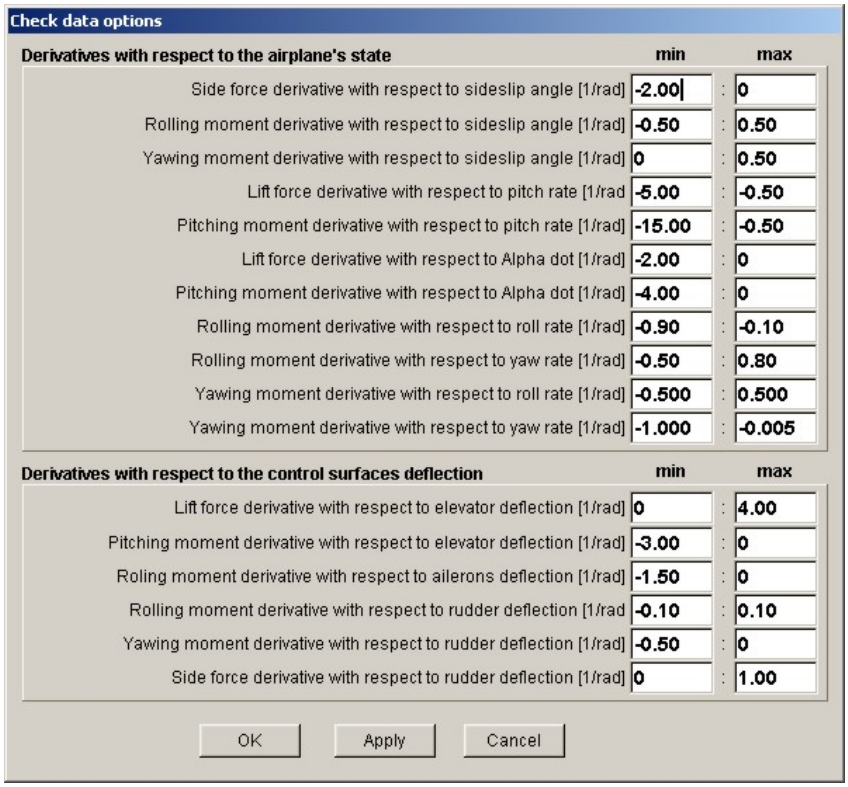

Check data options
Derivatives with respect to the airplane's state
min
max
Side force derivative with respect to sideslip angle [1/rad] -2.00 : 0
Rolling moment derivative with respect to sideslip angle [1/rad] -0.50 : 0.50
Yawing moment derivative with respect to sideslip angle [1/rad] 0 : 0.50
Lift force derivative with respect to pitch rate [1/rad -5.00 : -0.50
Pitching moment derivative with respect to pitch rate [1/rad] -15.00 : -0.50
Lift force derivative with respect to Alpha dot [1/rad] -2.00 : 0
Pitching moment derivative with respect to Alpha dot [1/rad] -4.00 : 0
Rolling moment derivative with respect to roll rate [1/rad] -0.90 : -0.10
Rolling moment derivative with respect to yaw rate [1/rad] -0.50 : 0.80
Yawing moment derivative with respect to roll rate [1/rad] -0.500 : 0.500
Yawing moment derivative with respect to yaw rate [1/rad] -1.000 : -0.005
Derivatives with respect to the control surfaces deflection
min
max
Lift force derivative with respect to elevator deflection [1/rad] 0 : 4.00
Pitching moment derivative with respect to elevator deflection [1/rad] -3.00 : 0
Roling moment derivative with respect to ailerons deflection [1/rad] -1.50 : 0
Rolling moment derivative with respect to rudder deflection [1/rad -0.10 : 0.10
Yawing moment derivative with respect to rudder deflection [1/rad] -0.50 : 0
Side force derivative with respect to rudder deflection [1/rad] 0 : 1.00
OK
Apply
Cancel

Fig. 3.8 - SDSA – Check data options external window

Information about SDSA check data options features:

- User can setup the *min* and *max* values of derivatives with respect to the airplanes state and the control surfaces deflections.
- These derivative values will be used to check the correctness of the loaded input aerodynamic data, (see chapter 3.1.3).

3.1.5 Data interpolation options …

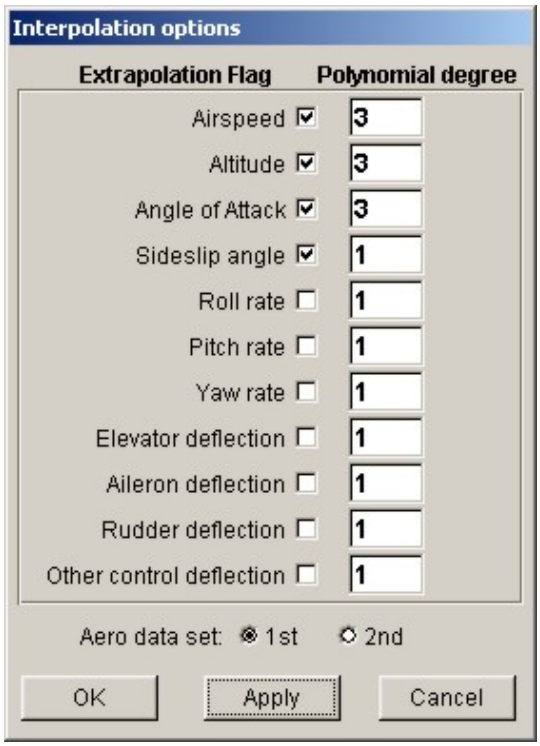


Fig. 3.9 - SDSA – Interpolation options external window

Information about SDSA interpolation options features:

- In some cases where input data is "poor", user can extrapolate the desired parameters.
- SDSA enables user to choose the data type to be extrapolated by selecting the proper *Extrapolation flag* and enter *Polynomial degree* of the extrapolation method.
- User can also choose the aero date set to be extrapolated *1st or 2nd*.
- The extrapolation is not valid for the aerodynamic derivatives – input data. (for more information see **SDSA – Input data file structure manual**)
- The interpolation doesn't depend on the aero input data type *TXT or XML*.

3.1.6 Propulsion system options internal window …

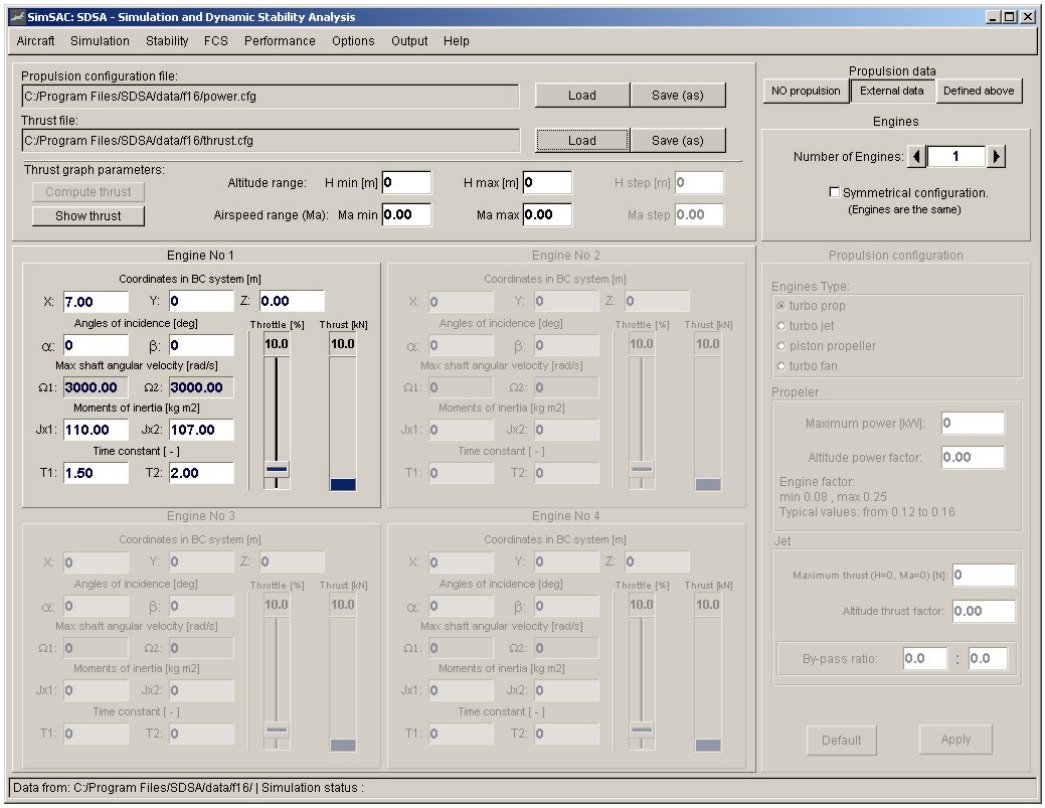


Fig. 3.10 - SDSA – Propulsion system internal SDSA window

Information about SDSA propulsion system options features:

- User can setup the main propulsion data by setting up the necessary parameters or by loading them from previously saved *Propulsion configuration file* and *Thrust data file*.
- The main propulsion system option window contains 4 *Engine panels* which turn active in agreement with the *Number of Engines* parameter value (max 4).
- There are panels where user can set up the basic *Propeller* and *Jet* properties, and select the *Engine Type*.
- User can compute the thrust with respect to the altitude airspeed range by clicking the *Compute thrust* button.

3.2 Simulation submenu

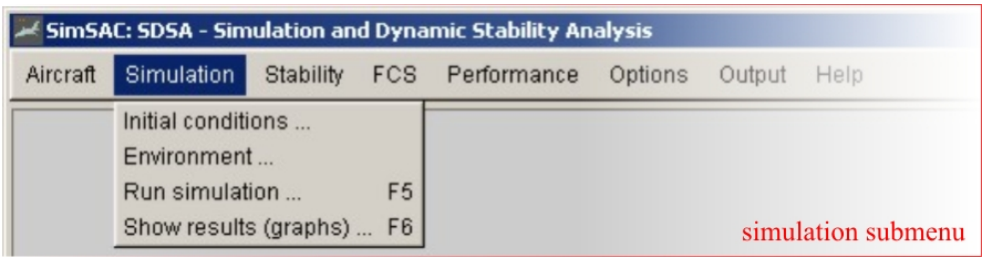


Fig. 3.11 - SDSA – Simulation submenu

Command	Short cut key combination	Description
Initial conditions …	-	- click to open external SDSA initial conditions setup window, (see Fig. 3.12),
Environment …	-	- click to open external SDSA environment setup window, (see Fig. 3.13),
Run simulation …	*F5*	- click to proceed to SDSA simulation module; internal SDSA simulation window appears, (see Fig. 3.14),
Show results (graphs)	*F6*	- click to show the SDSA simulation results (presented on graphs), (see Fig. 3.18),

Table 03 SDSA – Simulation submenu description

3.2.1 Initial condition …

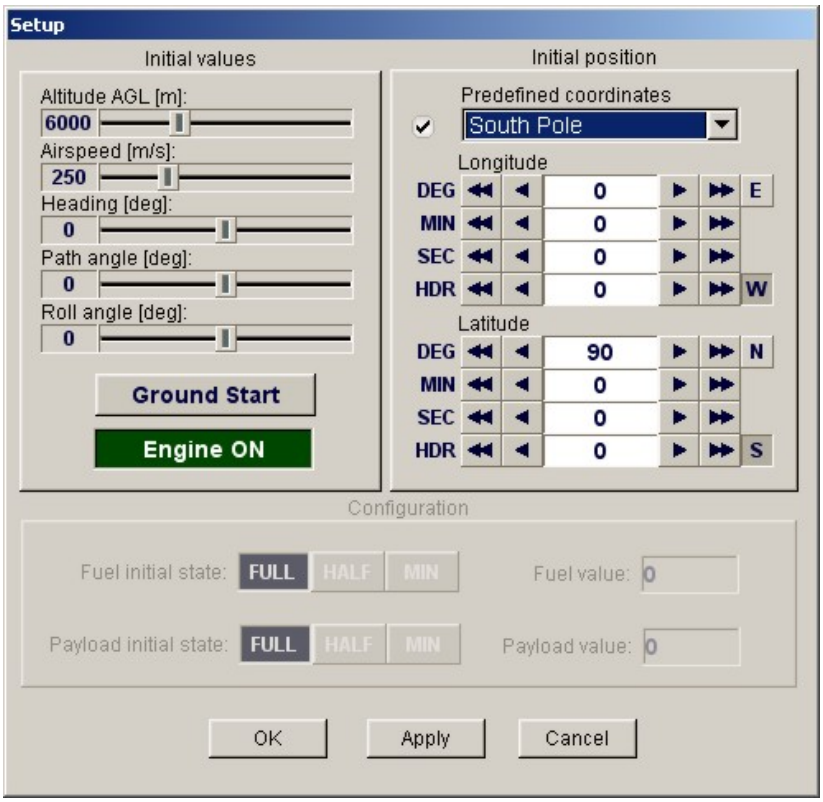


Fig. 3.12 - SDSA – external initial condition setup window

Information about SDSA initial conditions features:

- User can setup initial flight parameters and position values in external setup window.
- The initial parameter values will be used in aircraft simulation process!

3.2.2 Environment …

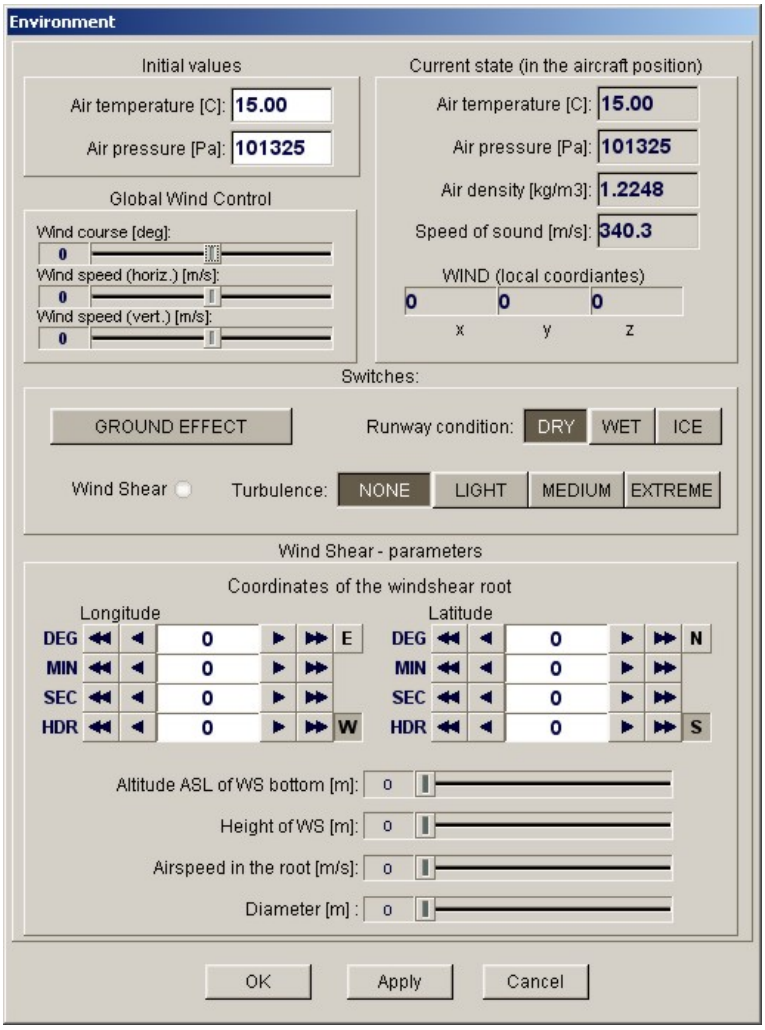


Fig. 3.13 - SDSA – external environment window

Information about SDSA environment features:

- User can setup environment features like:
- initial atmosphere parameters (air temperature, air pressure)
- wind gusts and global wind parameters (speed, etc.),
- runway conditions and turbulence parameters,
- The environment parameters will be used in aircraft simulation process!
- The future version of SDSA will have the Dryden turbulence model implemented!

3.2.3 Run simulation …

SDSA simulation mode enables to perform aircraft simulation, additionally it enables to observe the aircraft behaviour and flight data during the simulation process.

Information about SDSA simulation features:

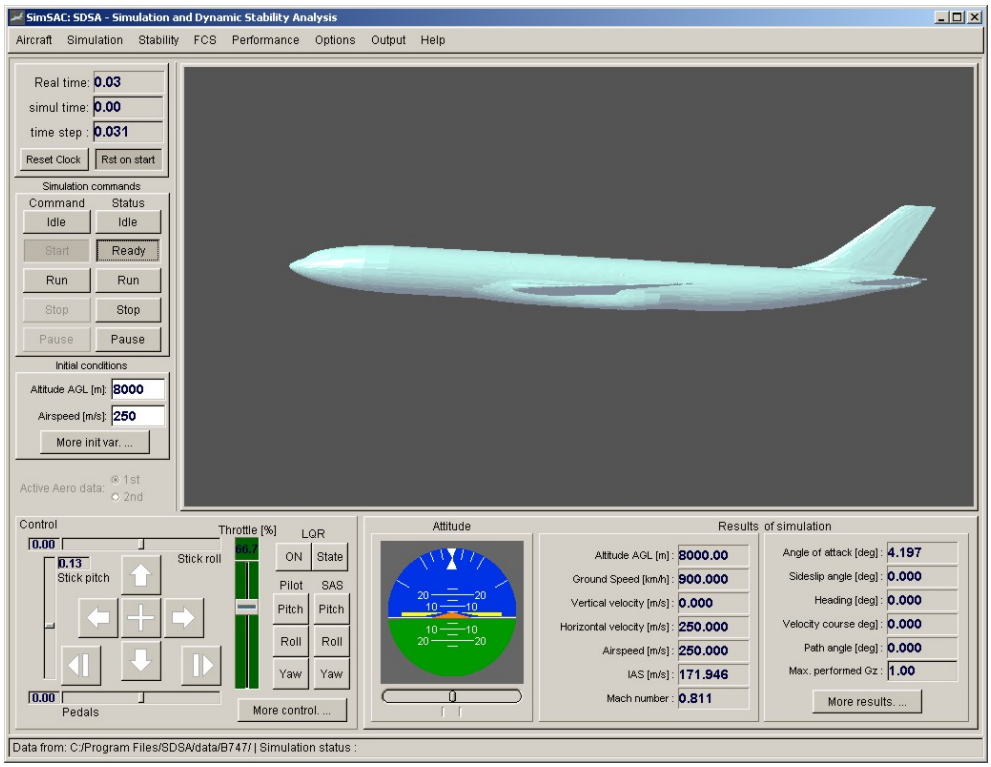


Fig. 3.14 - SDSA – Internal simulation window

- The SDSA simulation window is divided into several panels. The main panel is reserved for the 3D visualization of simulation process. Additionally the position of aircraft (during simulation process) can be watched on the HIS horizontal situation indicator (see Fig. 3.15).

Fig. 3.15 - SDSA – HIS indicator - internal simulation SDSA window

- The results of simulation (flight parameter values) can be observed in detail by clicking the *More results …* button in *Results of simulation* panel (see Fig. 3.14).

During simulation user can access the *Control* panel and change *Initial conditions*, (see Fig. 3.16).

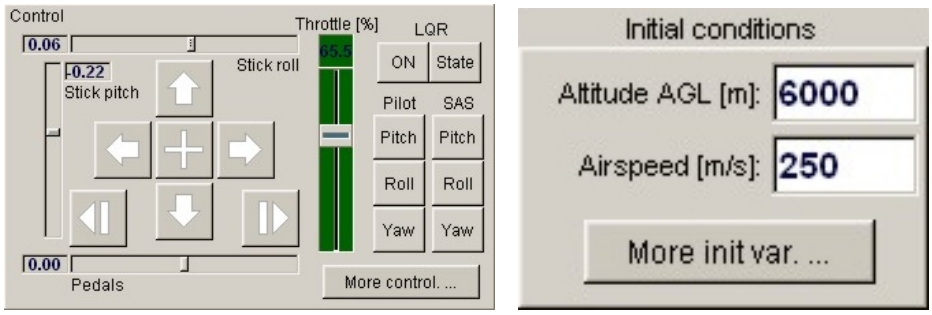


Fig. 3.16 - SDSA – Control and Initial conditions panel - internal simulation SDSA window

- *More control ...* and *More init var. ...* button gives access to the *Setup* and *Environment* external windows (see Fig. 3.13).
- *LQR ON* button enables the Linear Quadratic Regulator (see chapter 3.4.4) during the simulation process, (LQR works only when the FCS - Flight Control System matrices computation was made (see chapter 3.4.4 for more detailed information)).
- User can also turn on the *Pilot* – Pilot Control Model (see chapter 3.4) & *SAS* – Stability Argumentation System (see chapter 3.4) by clicking one of three control channels *Pitch*, *Roll* & *Yaw*.
- The State control button turns yellow when the flight parameters are meeting the desired boundaries.
- User can control the simulation process by clicking the adequate button in *Simulation commands* panel, (see Fig. 3.17).
- User can also activate the desired *Aero data* (1st or 2nd set) which will be used during the simulation process (only when more than one aerodynamic data set is available).

Fig. 3.17 - SDSA – Simulation commands panel - internal simulation SDSA window

- The *Simulation commands* panel is divided into two button column groups: *Command* and *Status* button group. Each *Status* button indicates if the *Command* button is ready to take action. When the simulation data is fully loaded both *IDLE* buttons turn dark grey (are pressed). Only now user can activate the simulation by clicking the *Start* button. When the status *Ready* button turns dark grey (is pressed) user can run the simulation by pressing *Run* button. To pause or stop simulation click the *Pause* or *Stop* button from *Command* button column.

3.2.4 Show results (graphs) …

SDSA show results (graphs) mode enables quick and easy simulation results review.

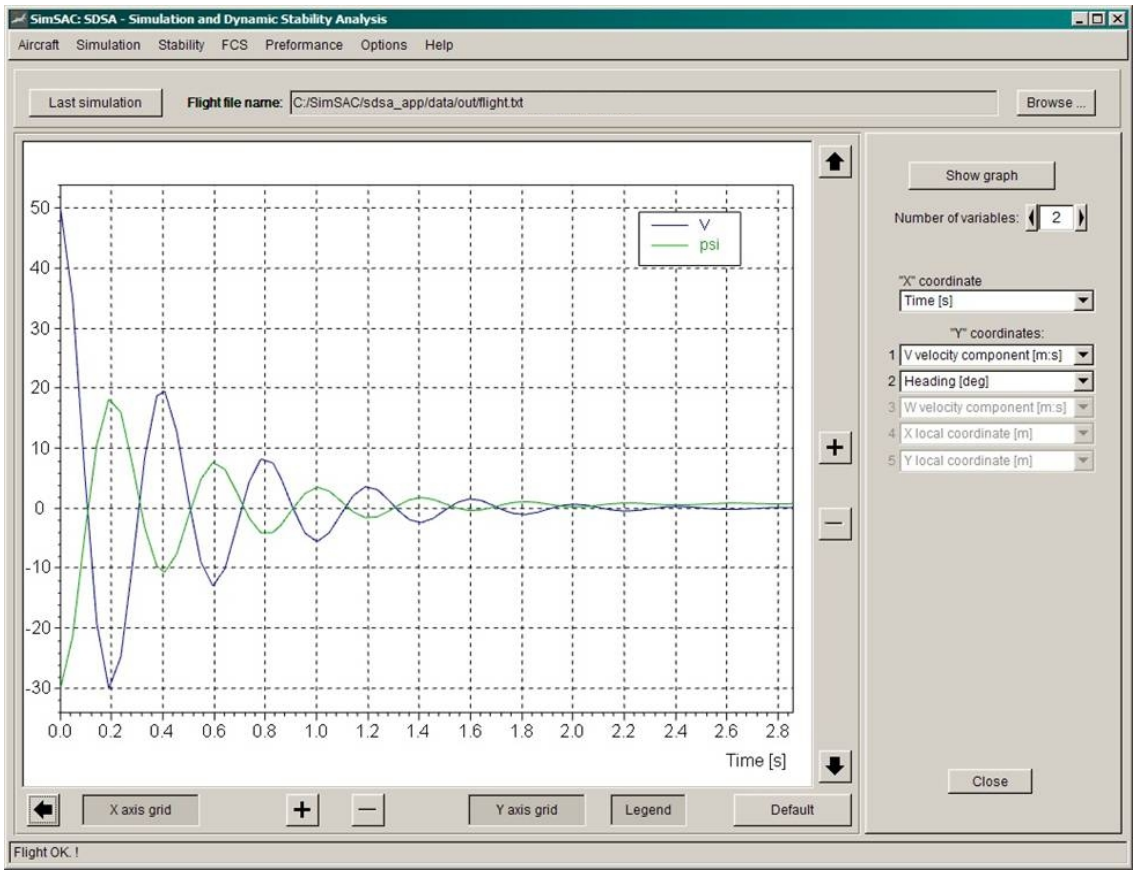


Fig. 3.18 - SDSA – Internal SDSA show results (graphs) window

Information about SDSA show results (graphs) features:

- User can setup in show results window:

- number and type of variables to display on graph,

- load saved simulation results and show them on graph,
  (click *Browse* button to point the results destination folder),

- show last simulation results, (*Last simulation* button must be pressed,
  this function is only active after the present simulation was finished).

- To exit the results window click *Close* button.

3.3 Stability submenu

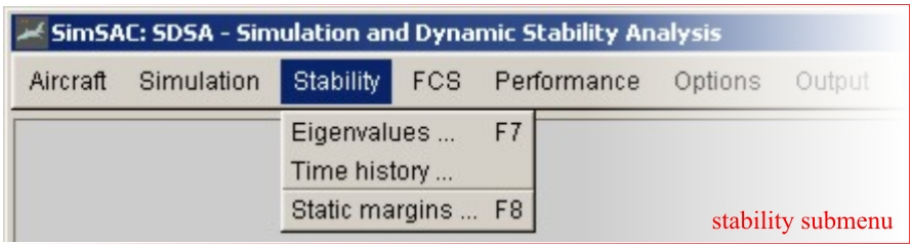


Fig. 3.19 - SDSA – Stability submenu

Command	Short cut key combination	Description
Eigenvalues ...	*F7*	- click to open internal SDSA eigenvalues stability functional window, (see Fig. 3.20, Fig. 3.21),
Time History...	-	- click to open external SDSA time history application window, (see Fig. 3.28),
Static margins ...	*F8*	- click to open internal SDSA static margins application window, (see Fig. 3.29),

Table 04 SDSA – Stability submenu description

3.3.1 Eigenvalues …

The SDSA eigenvalues mode enables user to perform stability and trim and stability linear computations for input aircraft data.

The GUI of SDSA eigenvalues mode has been prepared to meet the user requirements. Due to its simplicity it is easy to use. The trim and stability graph windows are arranged in groups: *Stability criteria*, *Stability characteristics* and *Trim results* to help user in navigating through the eigenvalues options.

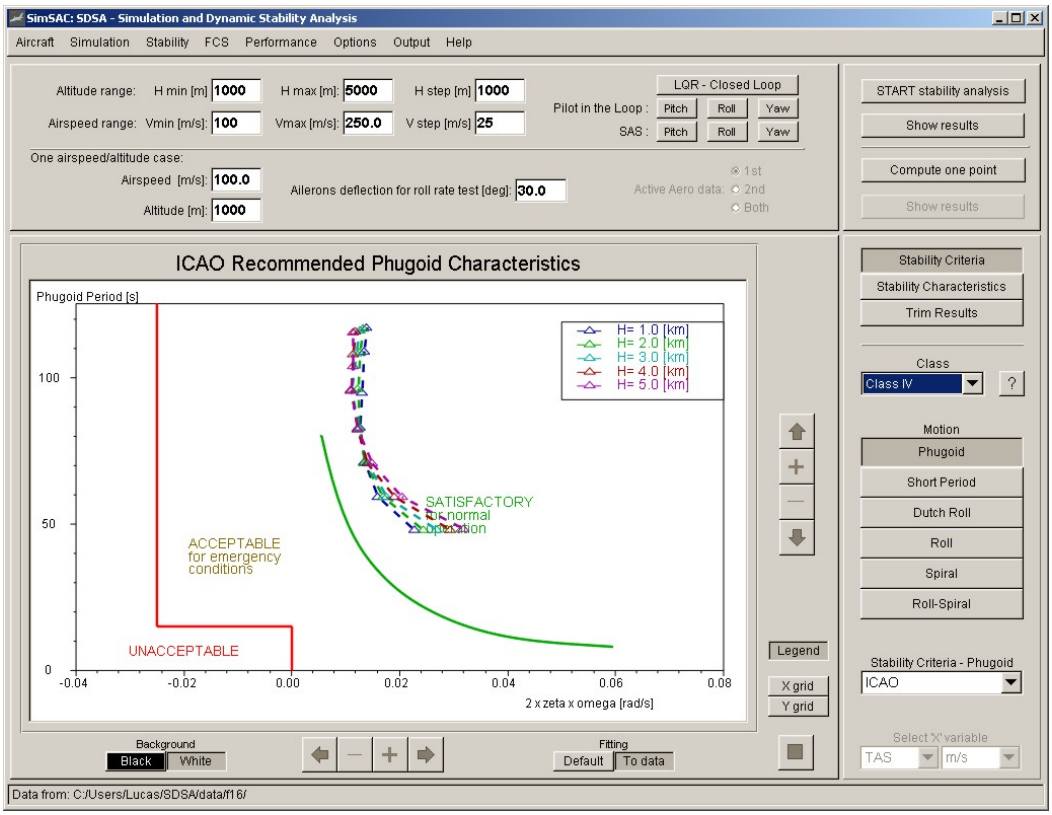


Fig. 3.20 - SDSA – Internal SDSA eigenvalues window (stability criteria mode)

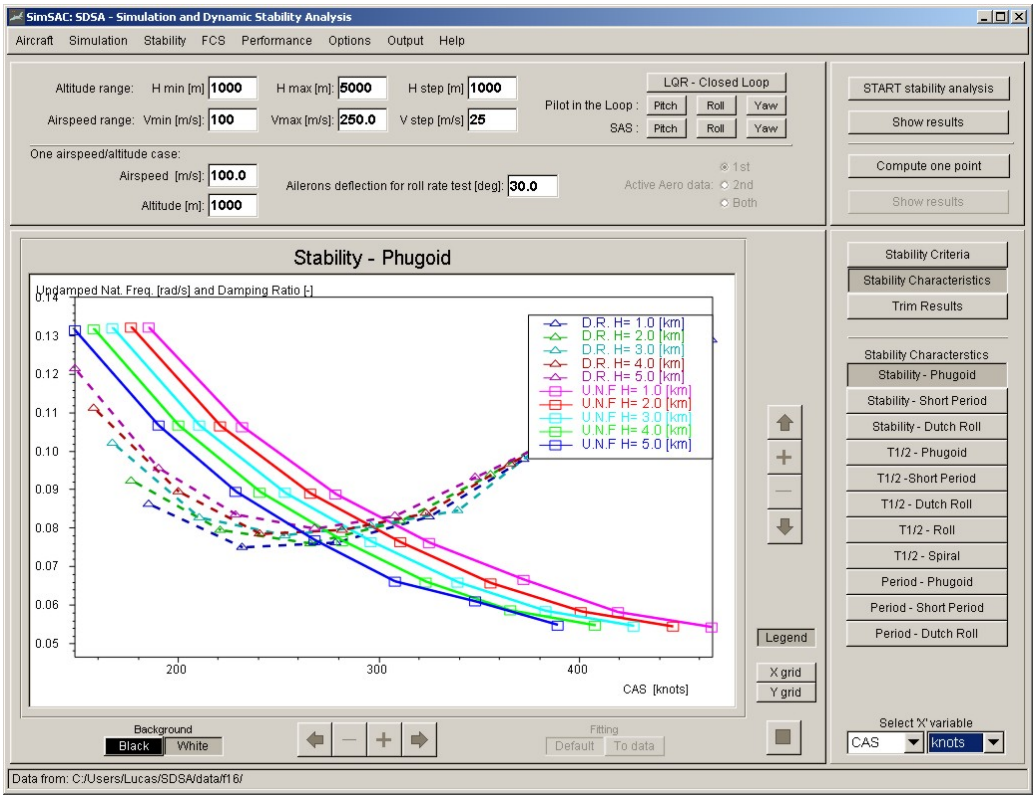

SimSAC: SDSA - Simulation and Dynamic Stability Analysis
Aircraft Simulation Stability FCS Performance Options Output Help
Altitude range: H min [m] 1000 H max [m]: 5000 H step [m] 1000
Airspeed range: Vmin [m/s]: 100 Vmax [m/s]: 250.0 V step [m/s] 25
LQR - Closed Loop
Pilot in the Loop : Pitch Roll Yaw
SAS : Pitch Roll Yaw
START stability analysis
Show results
Compute one point
Show results
One airspeed/altitude case:
Airspeed [m/s]: 100.0
Altitude [m]: 1000
Ailerons deflection for roll rate test [deg]: 30.0
Active Aero data: 1st 2nd Both
Stability - Phugoid
Undamped Nat. Freq. [rad/s] and Damping Ratio [-]
D.R. H= 1.0 [km]
D.R. H= 2.0 [km]
D.R. H= 3.0 [km]
D.R. H= 4.0 [km]
D.R. H= 5.0 [km]
U.N.F H= 1.0 [km]
U.N.F H= 2.0 [km]
U.N.F H= 3.0 [km]
U.N.F H= 4.0 [km]
U.N.F H= 5.0 [km]
CAS [knots]
Stability Criteria
Stability Characteristics
Trim Results
Stability Characterstics
Stability - Phugoid
Stability - Short Period
Stability - Dutch Roll
T1/2 - Phugoid
T1/2 -Short Period
T1/2 - Dutch Roll
T1/2 - Roll
T1/2 - Spiral
Period - Phugoid
Period - Short Period
Period - Dutch Roll
Legend
X grid
Y grid
Select 'X' variable
CAS knots
Background Black White
Fitting Default To data
Data from: C:/Users/Lucas/SDSA/data/f16/

Fig. 3.21 - SDSA – Internal SDSA eigenvalues window (stability characteristics mode)

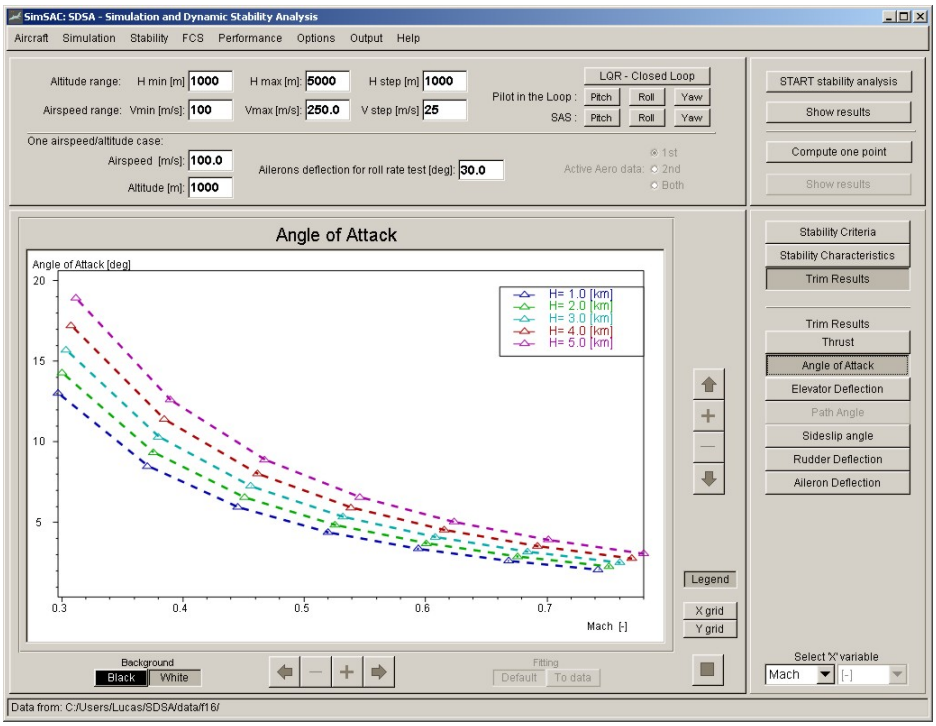


Fig. 3.22 - SDSA – Internal SDSA eigenvalues window (trim results mode)

- The SDSA eigenvalues mode is fully operational when aircraft input data was loaded. Before start of the stability analysis, user must enter the necessary input data: *Altitude* and *Airspeed* range with adequate iteration steps (see Fig. 3.23).

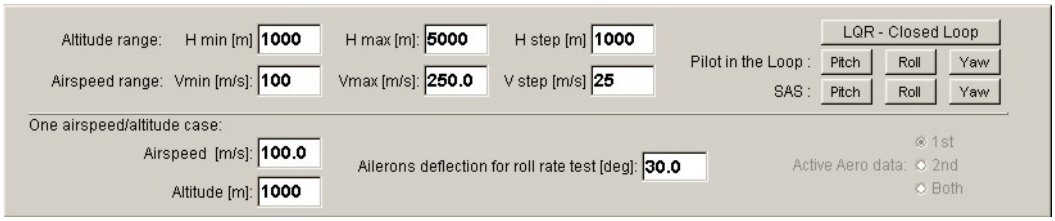

Altitude range: H min [m] 1000 H max [m]: 5000 H step [m] 1000
Airspeed range: Vmin [m/s]: 100 Vmax [m/s]: 250.0 V step [m/s] 25
LQR - Closed Loop
Pilot in the Loop : Pitch Roll Yaw
SAS : Pitch Roll Yaw
One airspeed/altitude case:
Airspeed [m/s]: 100.0
Altitude [m]: 1000
Ailerons deflection for roll rate test [deg]: 30.0
Active Aero data: 1st 2nd Both

Fig. 3.23 - SDSA – Internal SDSA eigenvalues window – input data panel

- Additionally user can turn on the *LQR – closed loop* or *Pilot in the loop* and *SAS computations*.
- User can also activate the desired *Aero data* (1^{st}, 2^{nd} or both) which will be used to compute the trim and stability results. This feature is active only when the loaded computational model has got 2 different aerodynamic input data sets.
- The SDSA offers two computation modes: *Compute one point* (for single point stability analysis) & *Start stability analysis* (for speed and altitude range multipoint analysis), depending on input data. To start computations click one of two push buttons.
- The SDSA prompts *"Stability analysis finished !"* when stability computations are done, and the *Show results* buttons turn active.

- When the stability computations are ended user can watch the stability results on main internal SDSA eigenvalues window (main graph panel, see Fig. 3.20, Fig. 3.21) or send them to the external text file *Show results* (see Fig. 3.24).

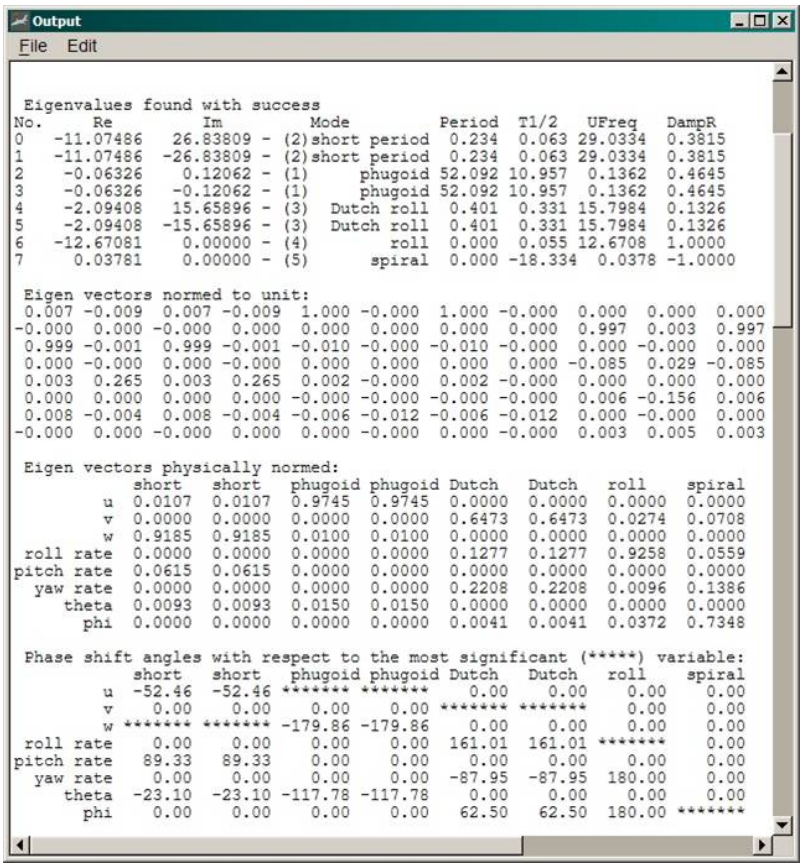


Fig. 3.24 -SDSA – Internal SDSA eigenvalues window – show results output window

- User can select between the *Stability criteria, Stability characteristics* or *Trim results* to being displayed by clicking the correct push button (see internal SDSA eigenvalues window right panel, see figure below).

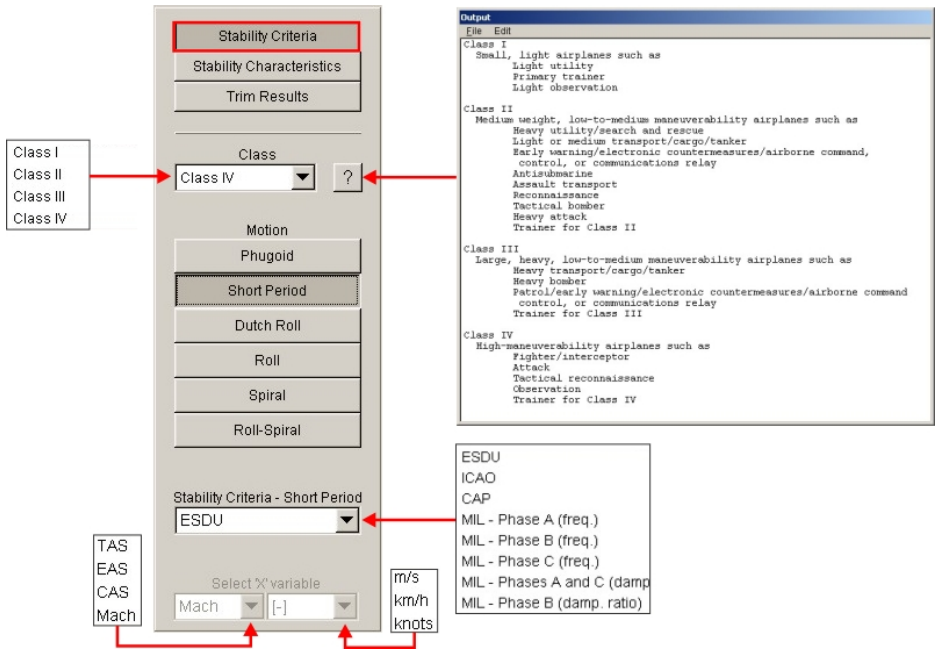


Fig. 3.25 - SDSA – Internal SDSA eigenvalues window – Stability Criteria selection panel

Fig. 3.26 - SDSA – Internal SDSA eigenvalues window – Stability characteristics selection panel

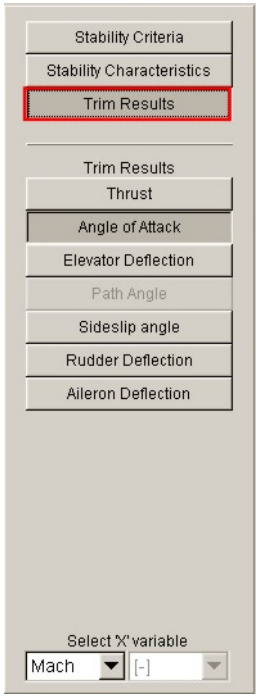


Fig. 3.27 - SDSA – Internal SDSA eigenvalues window – Trim results selection panel

3.3.2 Time history …

Time History is a useful external application for analyzing and identification of the periods, damping and phase shift from time response for specified aircraft data run case.

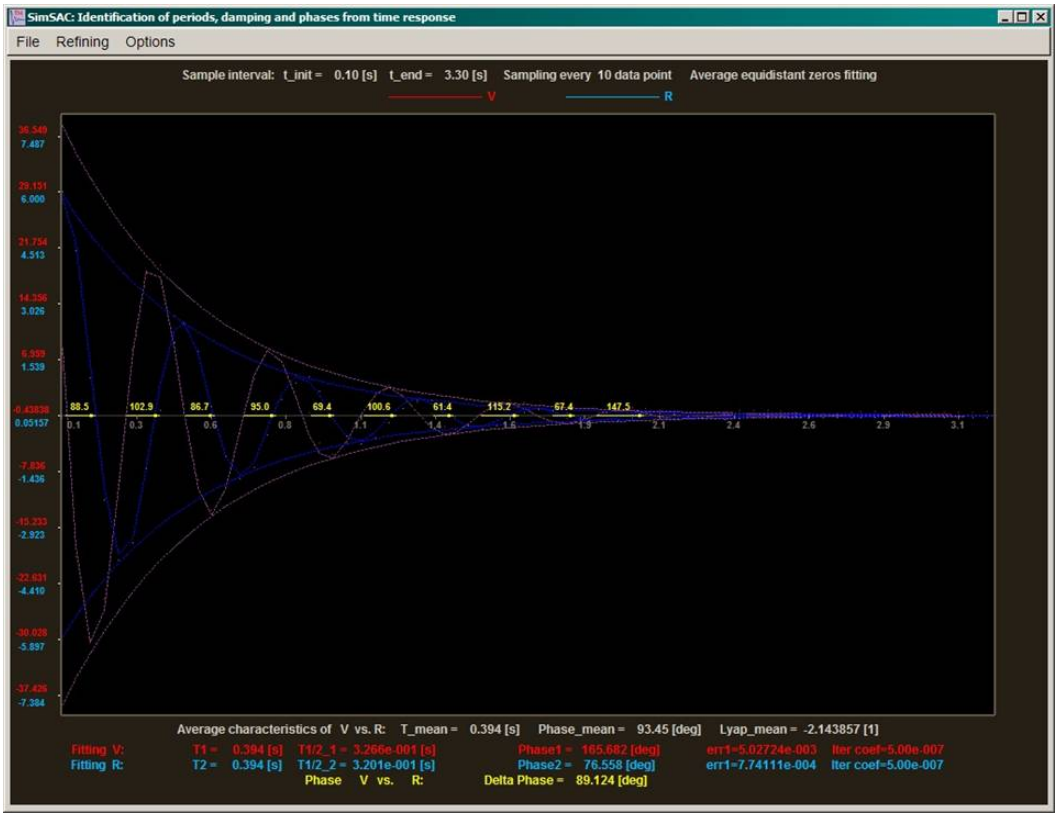

SimSAC: Identification of periods, damping and phases from time response
File Refining Options
Sample interval: t_init = 0.10 [s] t_end = 3.30 [s] Sampling every 10 data point Average equidistant zeros fitting
V
R
88.5
102.9
86.7
95.0
69.4
100.6
61.4
115.2
67.4
147.5
Average characteristics of V vs. R: T_mean = 0.394 [s] Phase_mean = 93.45 [deg] Lyap_mean = -2.143857 [1]
Fitting V: T1 = 0.394 [s] T1/2_1 = 3.266e-001 [s] Phase1 = 165.682 [deg] err1=5.02724e-003 Iter coef=5.00e-007
Fitting R: T2 = 0.394 [s] T1/2_2 = 3.201e-001 [s] Phase2 = 76.558 [deg] err1=7.74111e-004 Iter coef=5.00e-007
Phase V vs. R: Delta Phase = 89.124 [deg]

Fig. 3.28 - SDSA – External SDSA time history window

Brief information about time history features:

- The first time user starts time history analysis application prompts for data flight history input file, the default data path is set to flight recording data path, (see chapter 3.6.3).
- When input data is loaded, after a few seconds (depends on computer) the main time history window screen will change and the analysis results will be displayed.
- Important: After reading the input data file user can access the variable time history options or use the *Time history\Refining function* to refine results.

For more detailed information see *"Time history Software – brief user's manual"* !

3.3.3 Static margins …

Static margins mode is used to compute the static and controllability margins with stick fixed and free, for one more aerodynamic input data sets.

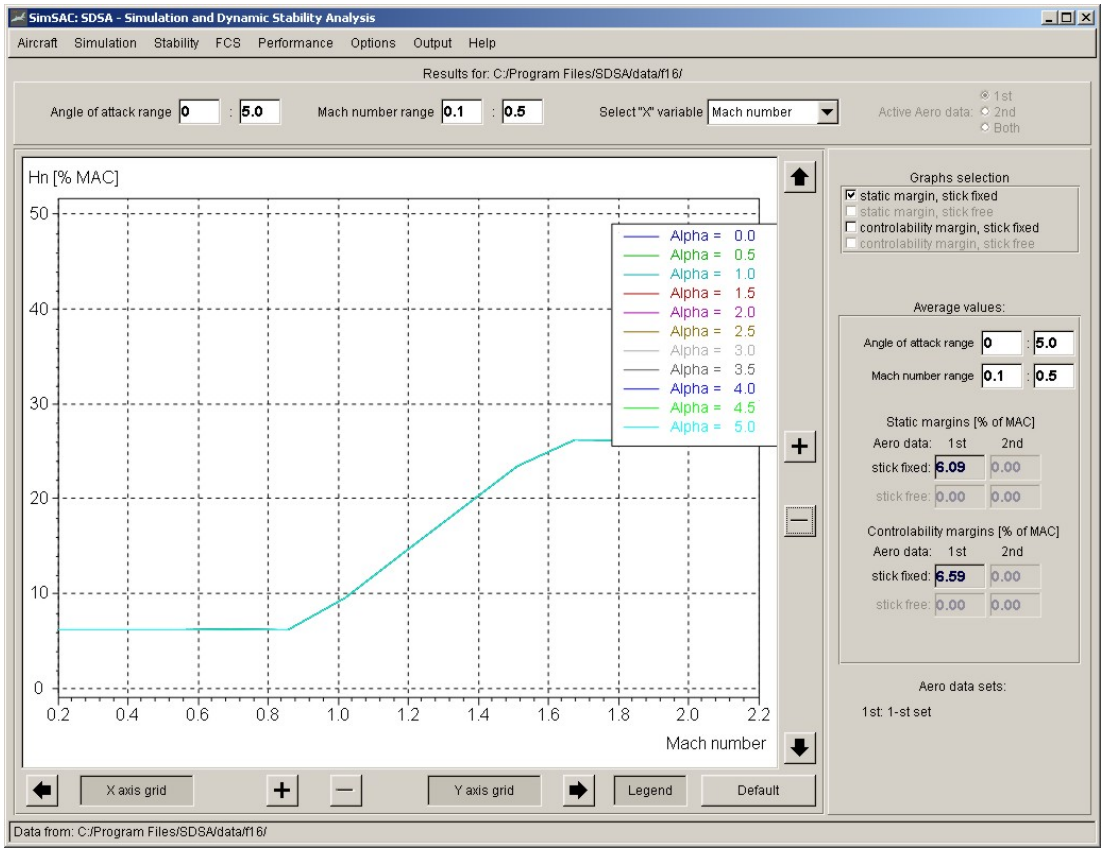


Fig. 3.29 - SDSA – Internal SDSA static margins window

Brief information about static margins features:

- Before computing the static margins user must load the input data.
- When input data is loaded, user can perform margins computations in respect to *Angle of attack range* and *Mach number range*.
- User can also activate the desired *Aero data set* for the static margins computations (if there is more than one aerodynamic data set defined in the input data).
- The obtained results are presented on 2D plot. Static margins can be displayed in function of *Mach number* or *Angle of attack*. Additionally the average values of static margins are given directly.

3.4 FCS - Flight Control System submenu

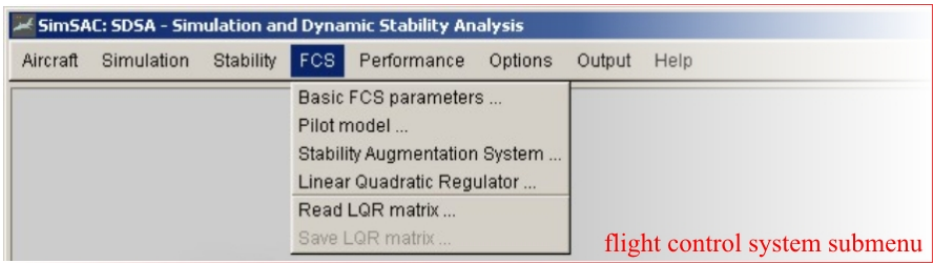


Fig. 3.30 - SDSA – FCS submenu

Command	Short cut key combination	Description
Basic FCS parameters …	-	- click to open internal setup SDSA Basic FCS parameters window, (see Fig. 3.31),
Pilot model …	-	- click to open Pilot in the Loop model, SDSA internal setup window, (see Fig. 3.32),
Stability Argumentation System …	-	- click to open Stability Argumentation System, SDSA internal setup window, (see Fig. 3.33),
Linear Quadratic Regulator …	-	- click to open main LQR SDSA internal setup window, (see Fig. 3.34),
Read LQR matrix …	-	- click to read LQR matrix, (see Fig. 3.37),
Save LQR matrix …	-	- click to save computed LQR matrix (activates after the LQR matrices has been created),

Table 05 SDSA – FCS submenu description

3.4.1 Basic FCS parameters …

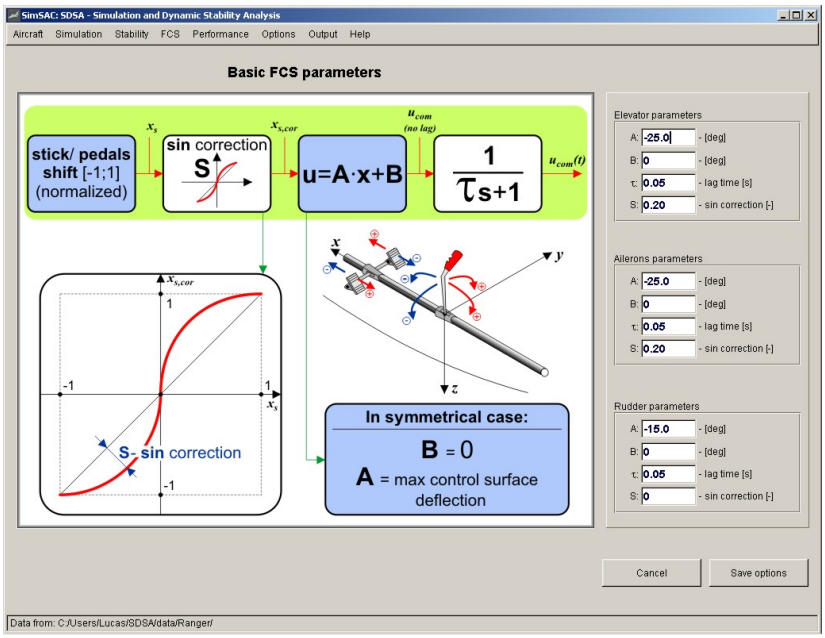


Fig. 3.31 - SDSA – Basic FCS parameters - setup window

3.4.2 Pilot model …

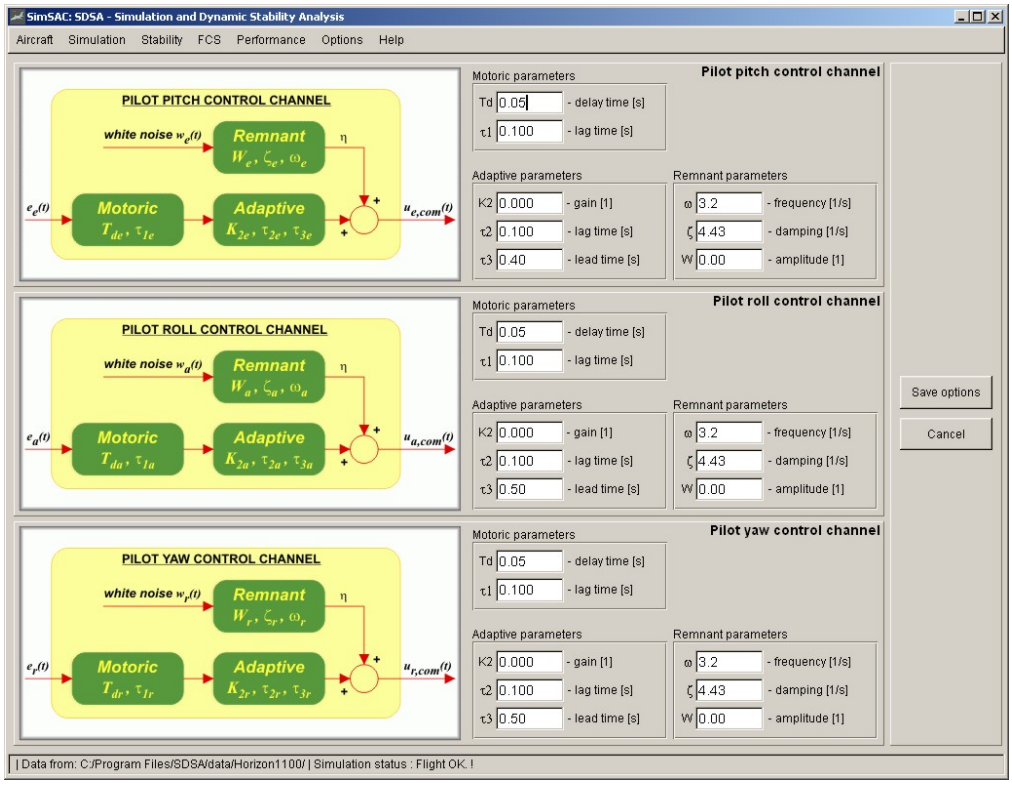

SimSAC: SDSA - Simulation and Dynamic Stability Analysis
Aircraft Simulation Stability FCS Performance Options Help
PILOT PITCH CONTROL CHANNEL
white noise
Remnant
Motoric
Adaptive
Pilot pitch control channel
Motoric parameters
Td 0.05 - delay time [s]
τ1 0.100 - lag time [s]
Adaptive parameters
K2 0.000 - gain [1]
τ2 0.100 - lag time [s]
τ3 0.40 - lead time [s]
Remnant parameters
ω 3.2 - frequency [1/s]
ζ 4.43 - damping [1/s]
W 0.00 - amplitude [1]
PILOT ROLL CONTROL CHANNEL
Pilot roll control channel
τ3 0.50 - lead time [s]
PILOT YAW CONTROL CHANNEL
Pilot yaw control channel
Save options
Cancel
| Data from: C:/Program Files/SDSA/data/Horizon1100/ | Simulation status : Flight OK. !

Fig. 3.32 - SDSA – Pilot in the loop parameters - setup window

3.4.3 Stability Argumentation System …

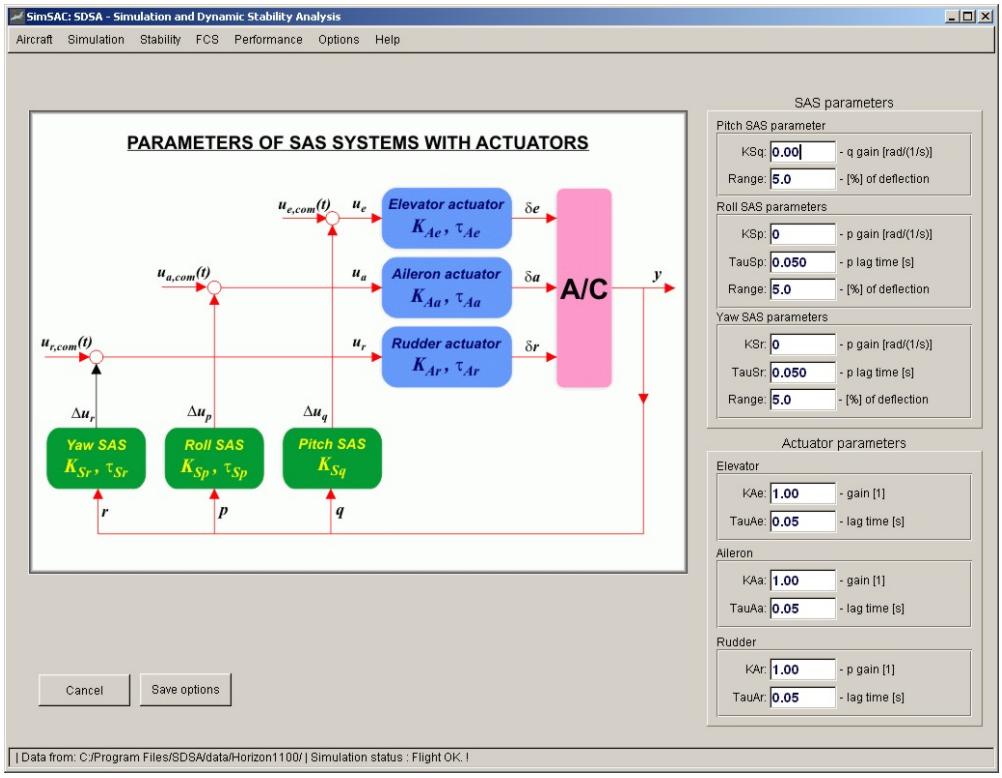

SimSAC: SDSA - Simulation and Dynamic Stability Analysis
Aircraft Simulation Stability FCS Performance Options Help
PARAMETERS OF SAS SYSTEMS WITH ACTUATORS
Elevator actuator
Aileron actuator
Rudder actuator
A/C
Yaw SAS
Roll SAS
Pitch SAS
SAS parameters
Pitch SAS parameter
KSq: 0.00 - q gain [rad/(1/s)]
Range: 5.0 - [%] of deflection
Roll SAS parameters
KSp: 0 - p gain [rad/(1/s)]
TauSp: 0.050 - p lag time [s]
Range: 5.0 - [%] of deflection
Yaw SAS parameters
KSr: 0 - p gain [rad/(1/s)]
TauSr: 0.050 - p lag time [s]
Range: 5.0 - [%] of deflection
Actuator parameters
Elevator
KAe: 1.00 - gain [1]
TauAe: 0.05 - lag time [s]
Aileron
KAa: 1.00 - gain [1]
TauAa: 0.05 - lag time [s]
Rudder
KAr: 1.00 - p gain [1]
TauAr: 0.05 - lag time [s]
Cancel
Save options
| Data from: C:/Program Files/SDSA/data/Horizon1100/ | Simulation status : Flight OK. !

Fig. 3.33 - SDSA – Parameters of SAS systems with actuators - setup window

3.4.4 Linear Quadratic Regulator

In Flight Control System mode user can *create FCS Matrices* (FCS envelope) for given altitude and airspeed range case or for *one computation point*. Currently FCS is based on the classical Linear Quadratic Regulator (LQR) approach [2].

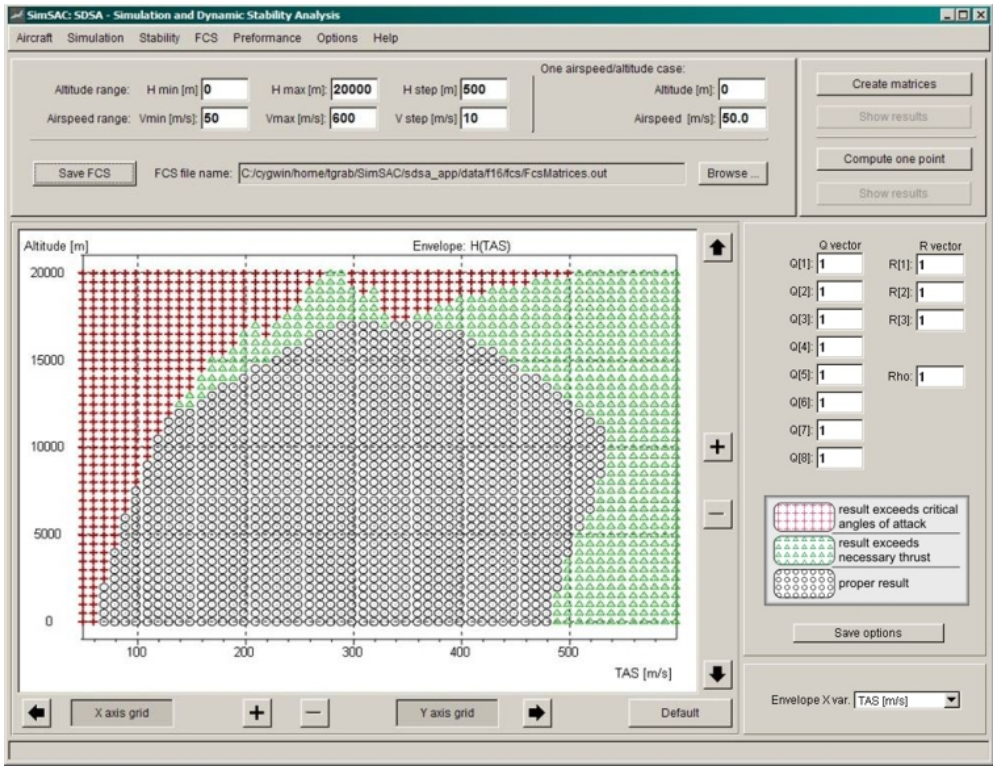


Fig. 3.34 - Internal SDSA LQR window – FCS matrices (FCS envelope)

- *LQR* - is the initial method of choice due to its simplicity, good robustness, ability to delivering desirable stability and performance properties and wide spreading in aerospace community.

Useful information about create FCS features:

- Before creating FCS matrices or computing single FCS point user must enter the necessary input data: *Altitude* and *Airspeed* range with adequate iteration steps (see Fig. 3.35). Additionally user can setup *Q & R vectors* (for more detailed information see D5.3-1 [2]).

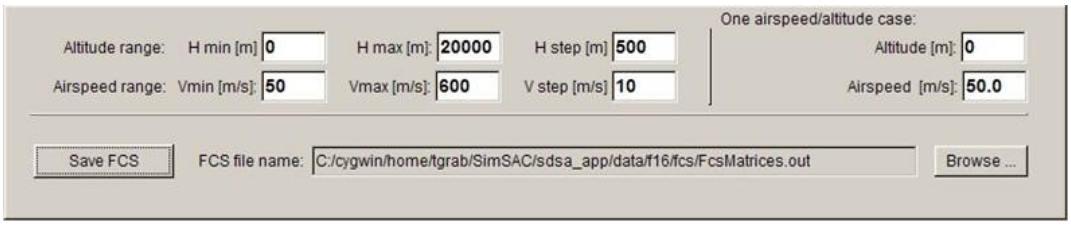
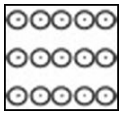


Fig. 3.35 - Internal SDSA create FCS window – input data panel

- Computing the FCS matrices can take some time depending on the computer, chosen airspeed and altitude range and steps. Application prompts *"Envelope analysis finished"* when envelope computations are finished.
- User can *Save FCS* or load (*Browse ...*) FCS by clicking the adequate application button.
- The quality of envelope results computation, needed to create FCS matrices are presented graphically (see Fig. 3.36), with use of colour marks:

- Result exceeds necessary thrust,

 - Proper results,

- Result exceeds critical angles of attack

Fig. 3.36 - FCS matrices results colour marks description

3.4.5 Read LQR …

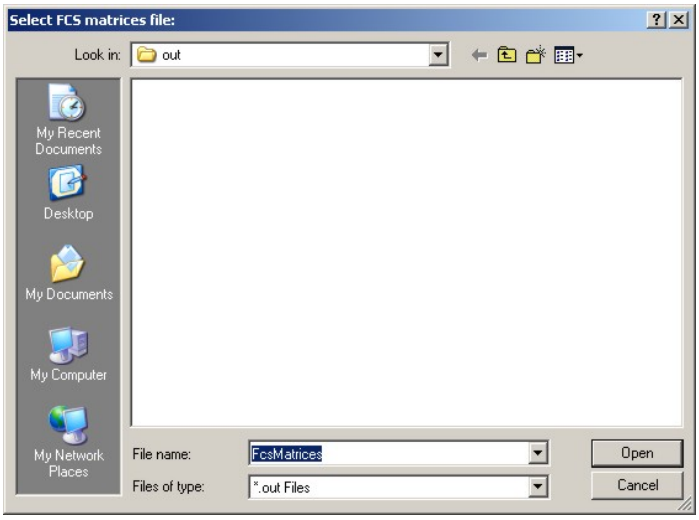


Fig. 3.37 - SDSA – FCS submenu – read LQR matrix - load data window

- User can read saved *LQR Matrix* data **.out* file, and use it in SDSA simulation mode (see chapter 3.4.4).

3.5 Performance submenu

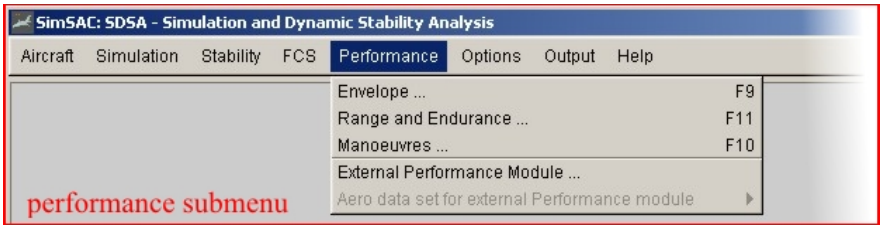


Fig. 3.38 - SDSA – Performance submenu

Command	Short cut key combination	Description
Envelope …	*F9*	- click to open internal SDSA envelope functional window, (see Fig. 3.39),
Range and Endurance …	*F11*	- click to open internal SDSA range and endurance functional window, (see Fig. 3.42),
Manoeuvres …	*F10*	- click to open internal SDSA manoeuvres functional window, (see Fig. 3.42),
External Performance Module …	-	- click to activate external SDSA performance module. (for more information see **SDSA – External performance module manual**)
Aero data set for External Performance Module	-	User can select *1st* or *2nd* aero data set for external performance module. (This option turns active if more than one data set is available) .

Table 06 SDSA – Performance submenu description

3.5.1 Envelope …

In envelope mode user can *Compute envelope* for given altitude range and altitude step. Additionally, the minimum and maximum airspeed and theoretical ceiling are being computed. Results are presented in output data fields and on graph for 1st or 2nd data set (if more than one set is available).

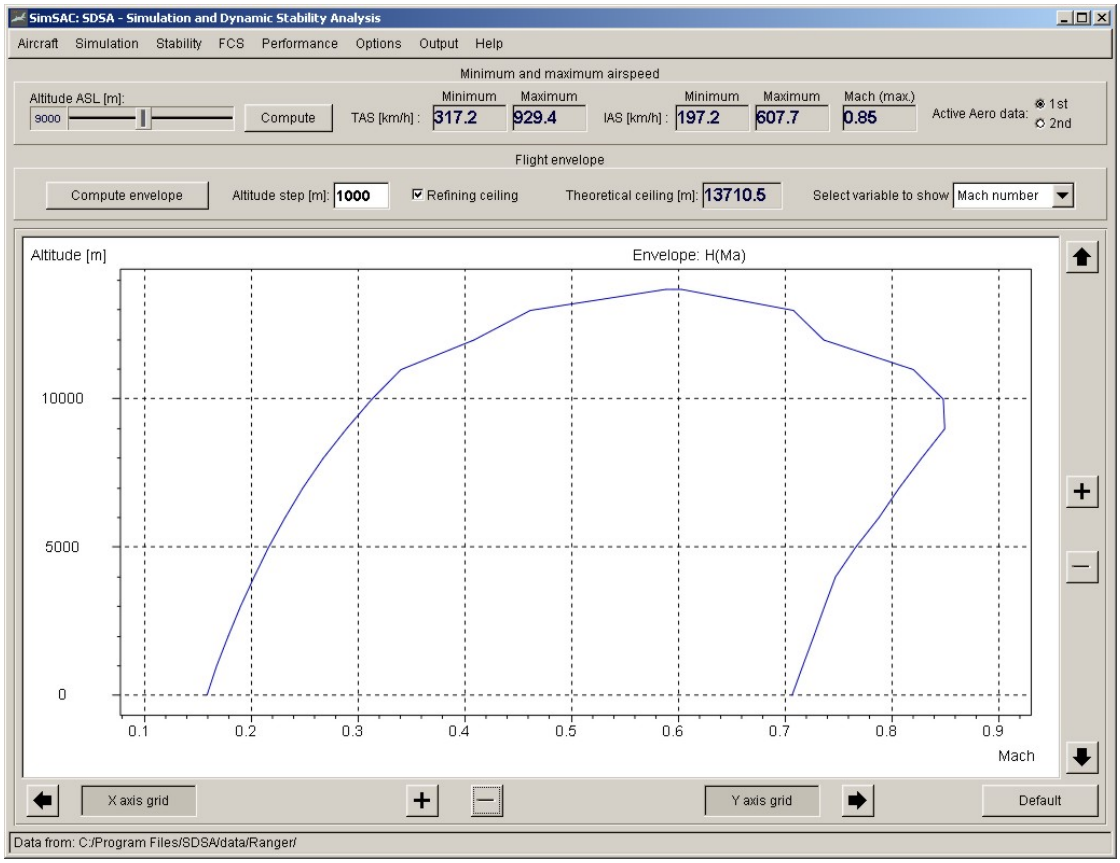


Fig. 3.39 - SDSA – Performance submenu – envelope functional window

Useful information about Envelope mode features:

- The envelope results can be presented in terms of altitude and Mach number or speeds (TAS, IAS & EAS). User can choose the desired "X" variable from drop down menu.
- Use Refine ceiling feature to refine the envelope results.

3.5.2 Range and Endurance …

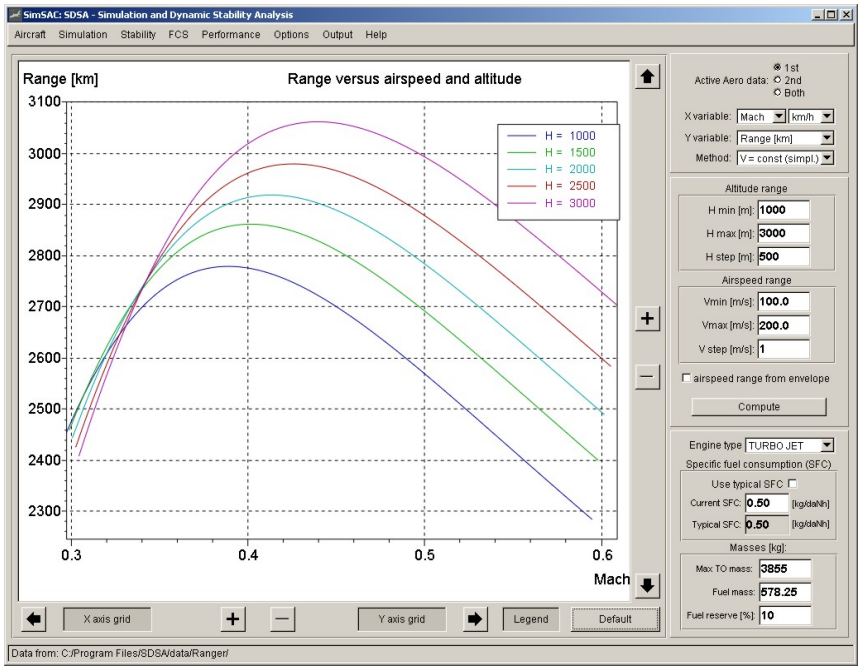


Fig. 3.40 - SDSA – Performance submenu – range and endurance functional window

In *Range and Endurance* SDSA performance feature user can perform range or endurance analysis for given altitude, airspeed range, engine type etc. To start analysis user must click *Compute* button. Results are presented in the graph window. Graph X and Y variable can be selected from the dropdown lists (see Fig. 3.41).

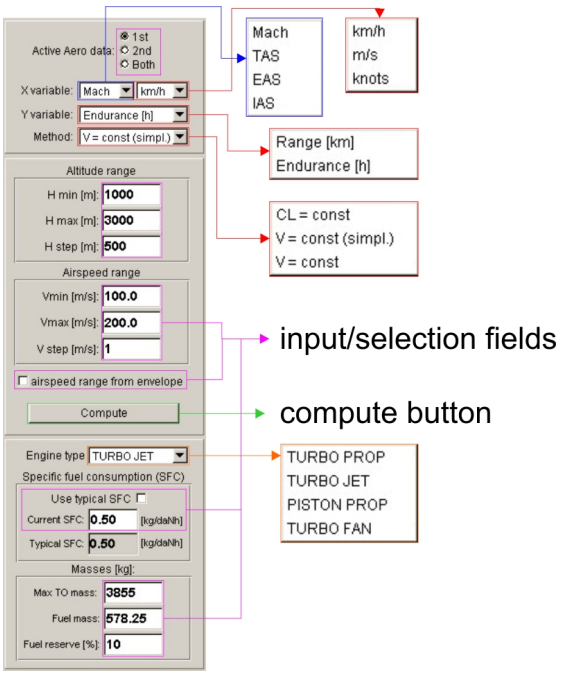


Fig. 3.41 - SDSA – Range and Endurance input fields and dropdown lists

3.5.3 Manoeuvres …

In Manoeuvres SDSA performance feature user can *Compute regular turn parameters* for given altitude, airspeed and roll angle. Results are presented in output data fields and in the graph window. To start selected analysis user must click *Compute* button. Graph X and Y variable can be selected from the dropdown lists (see Fig. 3.43).

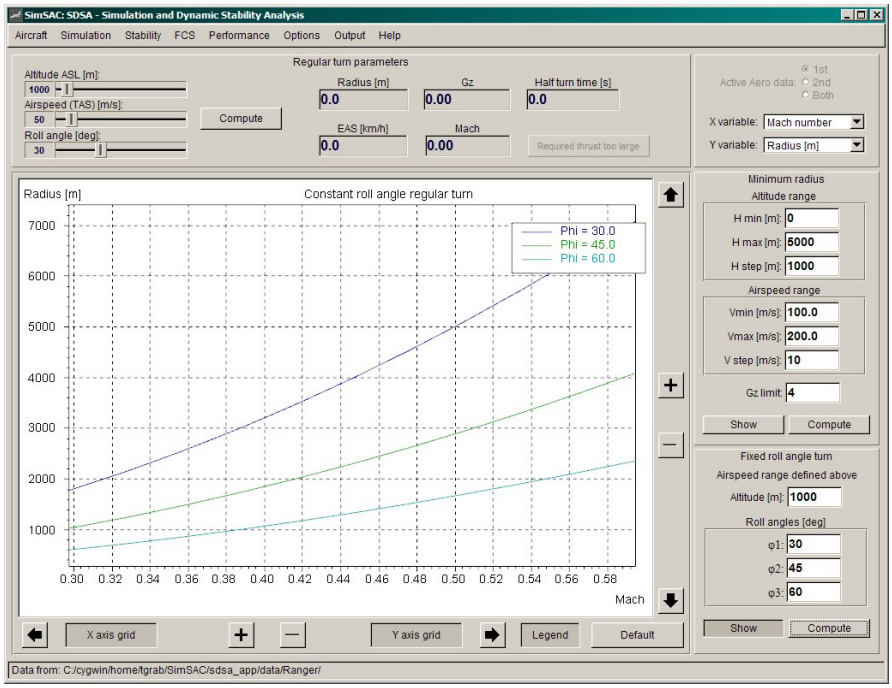


Fig. 3.42 - SDSA – Performance submenu – manoeuvres functional window

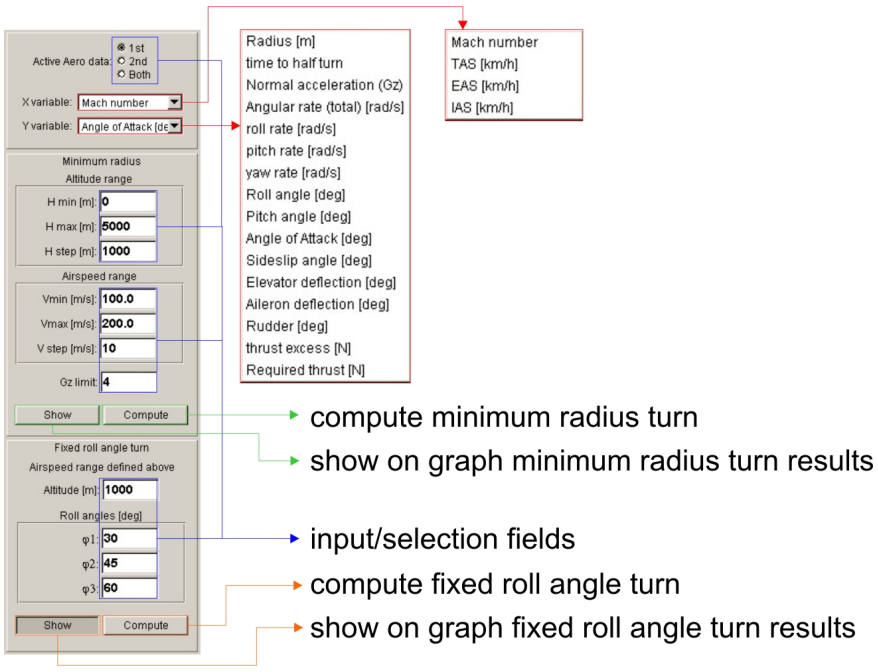


Fig. 3.43 - SDSA – Manoeuvres input fields and dropdown lists

3.5.4 External Performance Module - EPM…

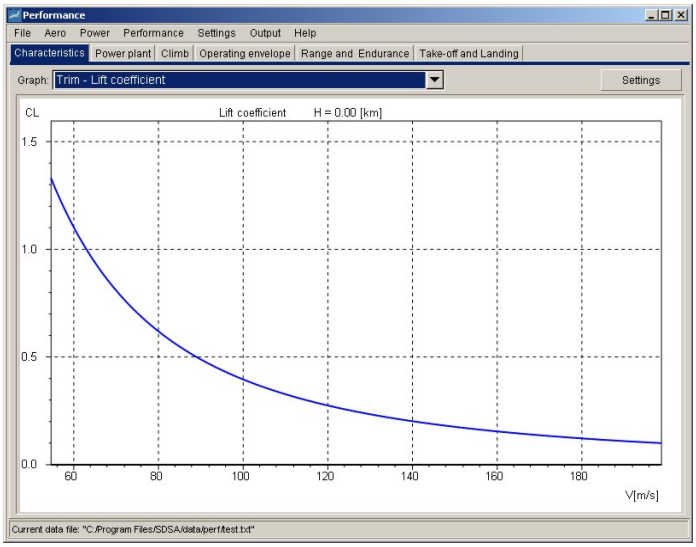


Fig. 3.44 - SDSA – Performance submenu – external performance module

When External Performance Module is activated the performance program window appears. The application is ready and user can work with the performance analysis results for current aircraft data (for more information see **SDSA – External performance module manual**).

3.6 Options submenu

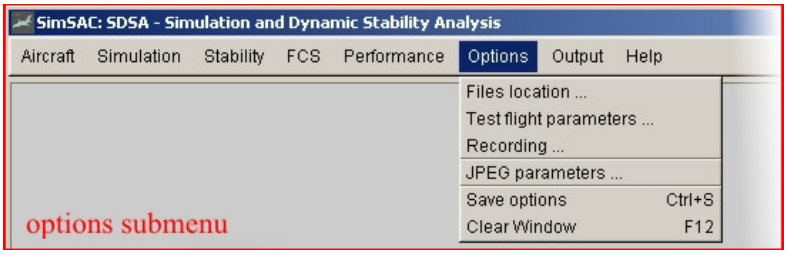

SimSAC: SDSA - Simulation and Dynamic Stability Analysis
Aircraft Simulation Stability FCS Performance Options Output Help
Files location ...
Test flight parameters ...
Recording ...
JPEG parameters ...
Save options Ctrl+S
Clear Window F12
options submenu

Fig. 3.45 - SDSA – Options submenu

Command	Short cut key combination	Description
Files location ...	-	- click to define folders for SDSA executable, data and output files, (see Fig. 3.46),
Test flight parameters ...	-	- click to activate the external SDSA test flight parameters functional window, (see Fig. 3.47),
Recording ...	-	- click to activate the external SDSA recording functional window, (see Fig. 3.48),
JPEG parameters ...	-	- click to define and save the capture output JPEG picture parameters, (see Fig. 3.49),
Save options ...	*Ctrl+S*	- click to save the SDSA options settings,
Clear window ...	*F12*	- click to clean the main application workspace window and display the start-up screen,

Table 07 SDSA – Options submenu description

3.6.1 Files location …

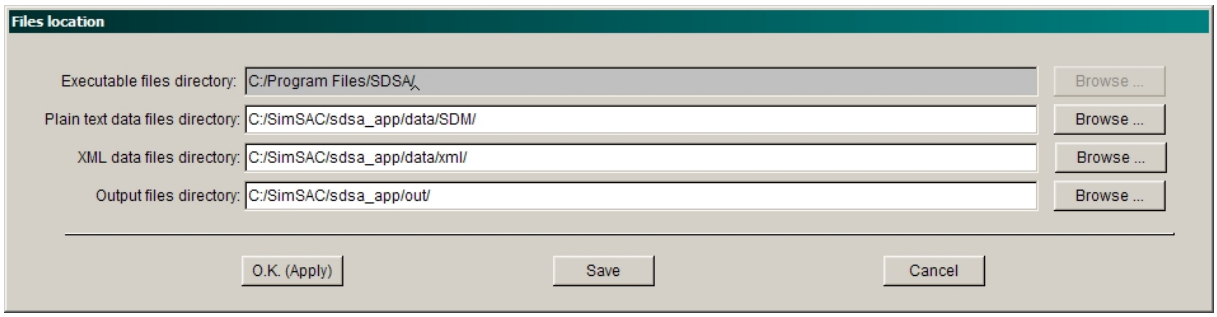


Fig. 3.46 - SDSA – Options submenu – SDSA folders selection for files location window

3.6.2 Test flight parameters …

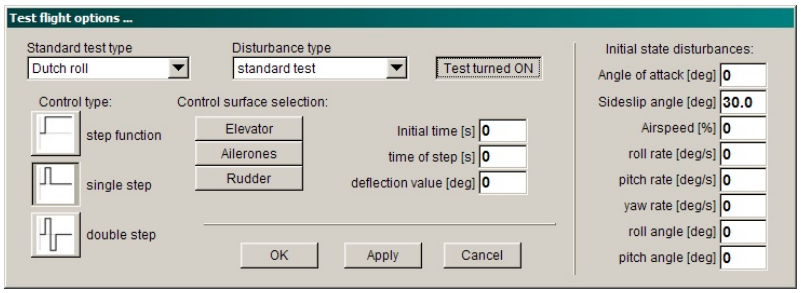


Fig. 3.47 - SDSA – Options submenu – SDSA test flight parameters setup window

In test flight parameters window user can setup the desired flight *Disturbance type*. The *Test turned On* button must be pushed in to activate the flight test. The effects of disturbance can be observed in simulation mode window (see chapter 3.2).

Useful information about test flight parameters mode features:

- In the test flight parameters mode user can choose the:

- control surface to be used during the disturbance,
- control type: step function, single step, double step,
- disturbance type,
- initial state parameters.

3.6.3 Recording …

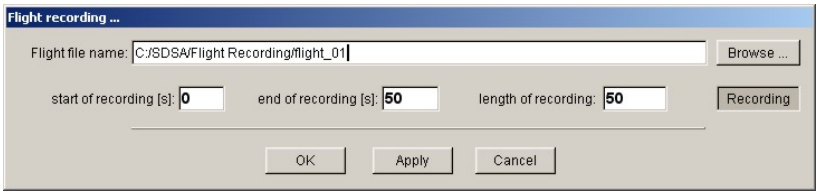


Fig. 3.48 - SDSA – Options submenu – SDSA flight recording setup window

In flight recording window user can setup the flight recording options like: flight recording file name and destination folder, start of recording time, end of recording time and length of recording. The *Recording* button must be pushed in to activate flight recording mode during simulation. The recorded flight simulation results (recorded in file) can be displayed in *Show results (graphs)*, (see chapter 3.2.4).

3.6.4 JPEG Parameters …

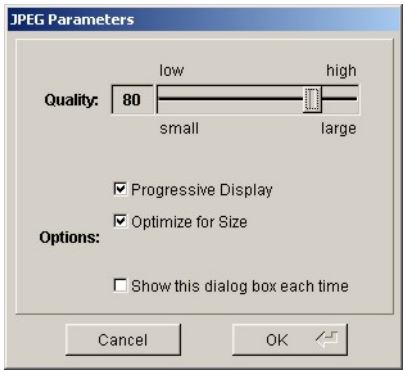


Fig. 3.49 - SDSA – Options submenu – SDSA JPEG Parameters setup window

In JPEG Parameters window user can setup the quality optimization options of the capture JPEG, (see also chapter 3.7).

3.7 Output submenu

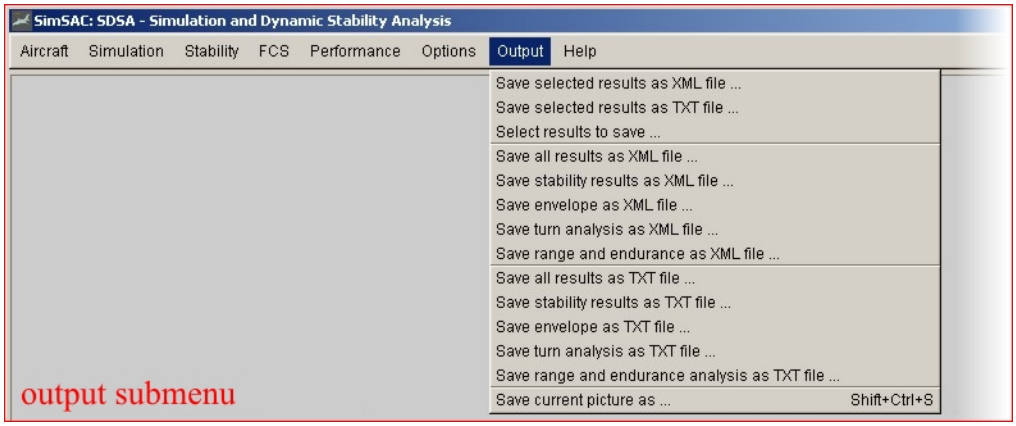

SimSAC: SDSA - Simulation and Dynamic Stability Analysis
Aircraft
Simulation
Stability
FCS
Performance
Options
Output
Help
Save selected results as XML file ...
Save selected results as TXT file ...
Select results to save ...
Save all results as XML file ...
Save stability results as XML file ...
Save envelope as XML file ...
Save turn analysis as XML file ...
Save range and endurance as XML file ...
Save all results as TXT file ...
Save stability results as TXT file ...
Save envelope as TXT file ...
Save turn analysis as TXT file ...
Save range and endurance analysis as TXT file ...
Save current picture as ... Shift+Ctrl+S
output submenu

Fig. 3.50 - SDSA – Output submenu

Command	Short cut key combination	Description
Save selected results as XML file ...	-	- click to save all (previously) selected SDSA results to one XML file.
Save selected results as TXT file ...	-	- click to save all (previously) selected SDSA results to one TXT file.
Select results to save ...	-	- click to open SDSA window (see Fig. 3.51) where user can select the results to save. Selected results will be written into one TXT ore XML file.
Save all results as XML file ...	-	- click to save all SDSA results to user selected XML file.
Save stability results as XML file ...	-	- click to save only SDSA stability results to user selected XML file.
Save envelope as XML file ...	-	- click to save only SDSA envelope results to user selected XML file.
Save turn analysis as XML file ...	-	- click to save only SDSA turn analysis results to user selected XML file.
Save range and endurance as XML file ...	-	- click to save only SDSA range and endurance results to user selected XML file.
Save all results as TXT file ...	-	- click to save all SDSA results to user selected TXT file.
Save stability results as TXT file ...	-	- click to save only SDSA stability results to user selected TXT file.
Save envelope as TXT file ...	-	- click to save only SDSA envelope results to user selected TXT file.
Save turn analysis as TXT file ...	-	- click to save only SDSA turn analysis results to user selected TXT file.
Save range and endurance as TXT file ...	-	- click to save only SDSA range and endurance results to user selected TXT file.
Save current picture as ...	*Shift+Ctrl+S*	- click to capture the current, active graph window with results to JPEG picture.

Table 08 SDSA – Output submenu description

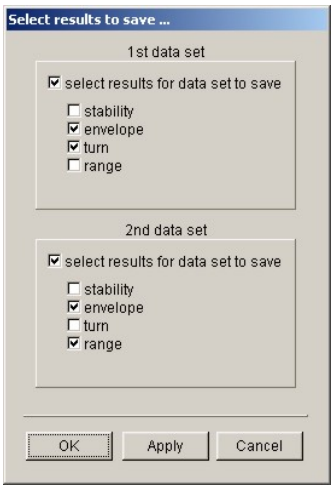


Fig. 3.51 - SDSA – Select results to save window

In *Select results to save* window user can choose which results to save. It is possible to save results from two aero data sets to a single file. It is very useful feature when one must make a results comparison.

3.8 Help submenu

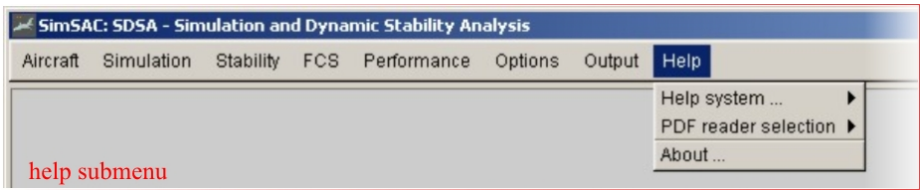


Fig. 3.52 - SDSA – Help submenu

Command	Short cut key combination	Description
Help system ...	-	Help system is a collection of PDF help files about SDSA application (see Fig. 3.53Fig. 3.55): 1) General help menu (press F1 key) 2) SDSA User manual 3) Theoretical basics 4) Main definitions 5) Data files description 6) Data analysis messages 7) Output files description
PDF reader selection ...	-	Here user can choose PDF reading software (see Fig. 3.54): 1) No PDF application 2) System default application 3) User selected SDSA user must point the path, (see Fig. 3.55) to the PDF reader (**PDF Reader** - submenu) when the **User selected** option is active.
About ...	-	- click to display the information about the SDSA team, (see Błąd: Nie znaleziono źródła odwołania),

Table 09 SDSA – Help submenu description

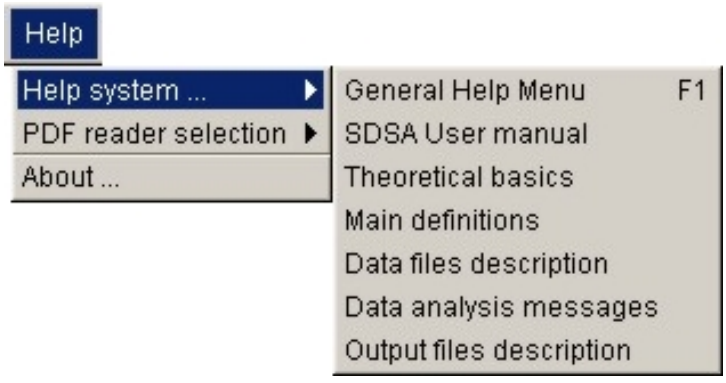


Fig. 3.53 - SDSA – Help system menu

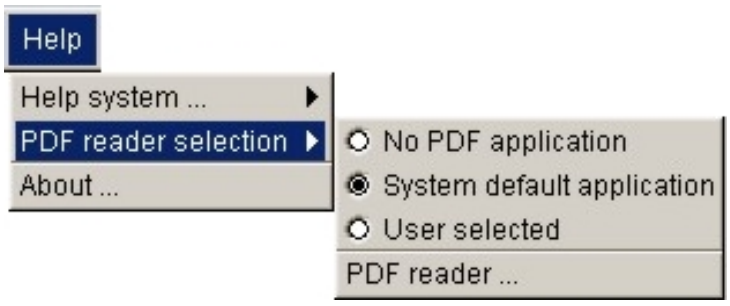


Fig. 3.54 - SDSA – PDF reader selection menu

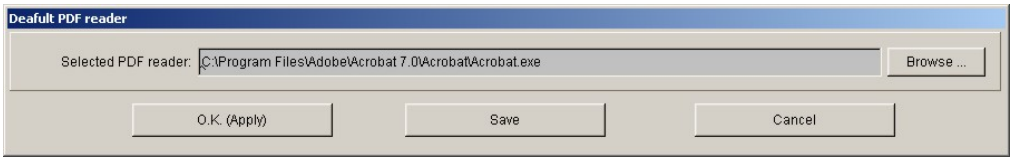


Fig. 3.55 - SDSA – PDF reader selection window

4 Implementation

SDSA was written in C++ and compiled using GNU C++ compiler. The Makefiles were written in a way, that allows compilation of sources under Linux and MS Windows (under Cygwin environment) as well. Compilation under MS Visual Studio is probably possible, without any changes but it hasn't been tested.

SDSA uses some mathematical routines library Alglib (http://www.alglib.net/) - all routines are licensed according to the 3-clause BSD. Compilation requires also windows widgets library FLTK (Fast Light Toolkit - http://www.fltk.org) and Fl_Native_File_Chooser widget (http://seriss.com/people/erco/fltk/Fl_Native_File_Chooser/). Both are provided under the terms of the GNU Library Public License, Version 2 with exceptions that allow for static linking To compile FLTK library the following configuration commands should be given:

Under Cygwin:

```
./configure --enable-localjpeg --enable-localpng --enable-localzlib
```

and under Linux:

```
./configure --enable-localjpeg --enable-localpng --enable-localzlib --enable-Xft
```

Native file chooser can be compiled directly using make command. The header files should be next copied into the include FLTK directory (usually /usr/local/include/FL) and main object should be copied into the FLTK library directory (usually /usr/local/lib).

5 Integration

The integration with CEASIOM environment is done by Matlab interface. The method of integration is presented on figure below.

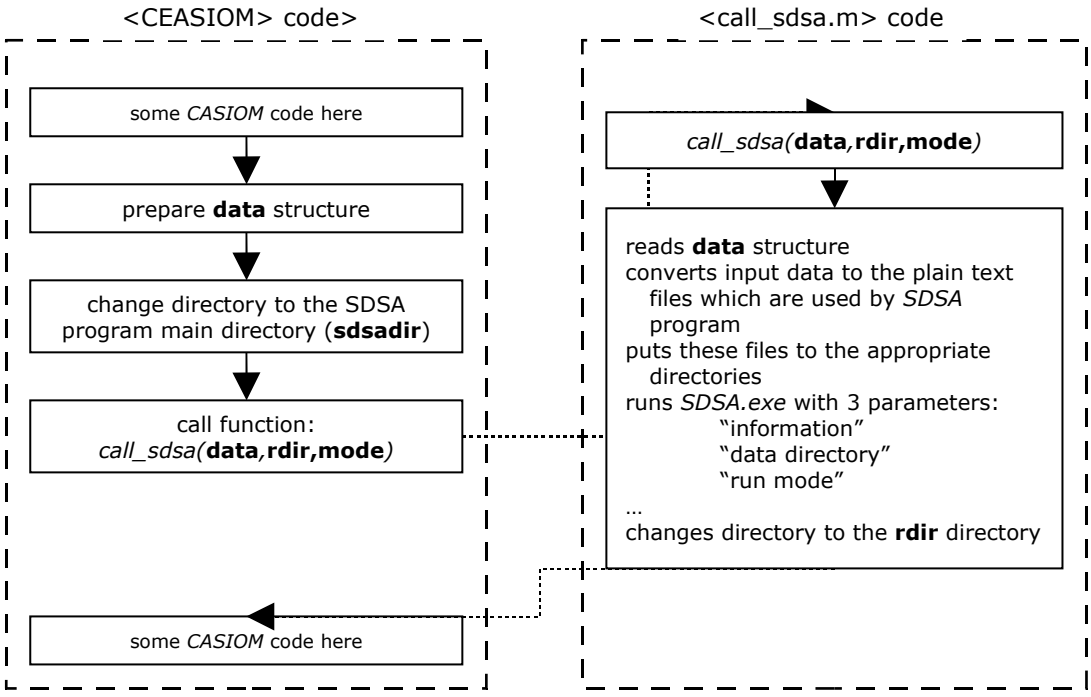


Fig. 5.2 – The scheme of SDSA-CEASIOM integration

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